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URBAN/MUNICIPAL

Hamilton Fire Department
Training Book 1

HAMILTON FIRE DEPARTMENT TRAINING MANUAL BOOK I

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CHAPTER I

FIRE SERVICE ORIENTATION AND INDOCTRINATION

1. INTRODUCTION - THE PROBATIONARY FIREFIGHTER

A young person in choosing a fire service career, should realize that firefighting methods must undergo constant change, revision and improvement to successfully control fire hazards relative to the flood of new chemicals, materials, articles, devices, etc., constantly becoming available to home and industry.

He will discover the fire service has advanced considerably in efficiency and effectiveness since the days of the horse-drawn steamers. Modern firefighting is receiving creditable recognition as a technical protective science, extremely important to the welfare of the nation. As such, it rates equally with any other trade, occupation or profession he might have chosen.

Firefighting demands much from those who would successfully follow it as a career. In return, it offers a life work of exciting safety service to the community, security, and excellent opportunities for advancement.

There is a difference between working for a private fire company and for a municipality. Citizens are inclined to be more or less critical of their public employees, expect members of its Fire Department to be neat, courteous, honest, moral, of good conduct and able to meet financial obligations. Failure on the part of the probationary firefighter to maintain this excellent departmental reputation may mean dismissal. He is expected to conduct himself accordingly as long as he remains a member of the department.

The actions of one member often reflect upon the entire department.

The good fellowship that is traditionally prevalent throughout the department will impress the probationary firefighter. The high morals and comradeship of men doing a good job in an occupation which borders on the dangerous, will be sensed almost immediately.

The probationary firefighter can share and become a part of this in a surprisingly short time, provided he indicates a willingness to co-operate and to learn. With the right attitude he will find his co-workers accept him. They (as ex-probationary firefighters themselves) will help him as much as possible and will make him feel that he "belongs".

If, on the other hand, he has a know-it-all complex and a why-not-do-it-a-different-way attitude, he is choosing the quickest way to win no influence or fire service friends. Firefighting is generally based on methods of proven maximum safety to personnel. Talk and suggestions by new members attempting to prove the extent of their knowledge always indicates a woeful lack of it, as far as experienced firefighters are concerned.

The wise probationary firefighter says little, but asks and learns much. The fire station boaster says much, but asks and learns little. He also leads a surprisingly lonely existence.

In this fire department, as in other progressive fire departments, a semi-military routine is employed as a means of providing effective and efficient departmental operation. Officers of the department assume responsibility for each operation, and orders given by them are to be obeyed without question.

(1986)

Discipline is absolutely necessary so that the department will function successfully and fires will be efficiently extinguished.

The highest ranking officer at the fire or emergency is in charge. His orders take preference over all others.

The probationary firefighter, realizing orders and commands may be based upon conditions of which he is unaware, must obey them without question to the best of his ability. He should have confidence in his company officer and should remain with him at fires or other emergencies until ordered elsewhere.

Firefighting companies may be considered as teams whose effectiveness depends upon a high degree of teamwork and co-operation on the part of each member of the company. As a member of this team, the probationary firefighter can be most useful by quickly and completely performing the duties assigned to him. His job, as a member of the department, is to constantly provide the maximum fire protection possible for the lives and property of the people of the City of Hamilton.

The probationary firefighter should never use his official position to secure advantages for himself. Such practices discredit the entire department. Local businessmen and citizens are paying firefighters' salaries as taxpayers and should not be approached for additional favours by members of the department.

The honesty and trustworthiness of firefighters must be unquestionable, because it is often necessary for them to enter homes and business establishments under emergency conditions with or without the knowledge of the owners. Complete faith in the integrity of department personnel by the people of the city is imperative. It is the duty of the probationary firefighter, as well as every other member of the department, to take special precautions with valuables by placing them in the hands of company officers or by directing attention to them.

(1986)

Firefighters must work at many things at fires and at fire stations. Some tasks can be readily performed by the probationary firefighters, others by more experienced personnel. The new members should not become discouraged at the prospect of performing the numerous small and seemingly unimportant jobs that fall to the lot of the beginner in the fire service. He should perform his assigned tasks willingly and well, keeping in mind the fact that he is constantly preparing himself for the more responsible duties. These will be assigned to him when he demonstrates he is capable of performing them.

The progress and promotion of any member of the fire department is depending upon his knowledge and his ability to assume additional responsibilities. Competition will be keen for any promotion the probationary firefighter may later seek. The habits formed doing good work at fire stations, at fires, obtaining excellent grades in probation and yearly service rating will play a decisive and important part in his future. Good firefighters, as a rule, make good fire officers.

The probationary firefighter should quickly become familiar with the location of firefighting equipment and appliances carried on the various fire apparatus to which he is assigned. Although his ability to use this equipment may need further developing, valuable time will be saved at emergencies if he knows where needed equipment is to be found on apparatus.

There is no substitute for experience in firefighting, for there are few fields of endeavour which experience is so necessary and so valuable.

It will soon be apparent to the probationary firefighter that firefighting experience becomes the prime mover and the deciding factor in nearly every split-second decision firefighters must make at fires or other emergencies with which they contend.

(1986)

In this sense, fires make good firefighters. But a firefighter is not allowed the mistakes men in other professions may make while gaining experience. He has few opportunities to remedy his errors and he is seldom allowed a second guess. His failure to do the right thing FIRST may result in additional loss to life and property.

A firefighter, obviously, cannot wait until fires or other emergencies occur to secure the practical knowledge he should have or the experience he so vitally needs. He learns much at fires, but his success as a firefighter will also depend upon how quickly or how well he assimilates the experience of other firefighters by means of study and training.

The people of Hamilton have confidence in their Fire Department. They are proud of it because it has always provided efficient fire protection for their homes, families and business establishments. This efficiency, as the probationary firefighter will discover, is the result of constant training and study by officers and men of the Department to secure the knowledge of fire prevention, fire protection and firefighting procedure that is necessary to successfully combat fire in our municipality.

The probationary firefighter is likewise expected to devote himself to the job of becoming a good firefighter. The firefighting knowledge and training he must secure is summarized in the Department Training Manual and also in the various other texts available to him. This knowledge, while extensive, is not difficult to secure, provided the new member makes conscientious and diligent efforts to obtain it. He will be given all possible aid and assistance in his efforts to become a good firefighter by:

- A. Multiple opportunities to study and train during leisure time.
- B. Personal instruction and training by competent officers and members of the Department while on duty.

(1986)

- C. Being able to actually see, handle and use firefighting tools appliances and equipment.
- D. Opportunities to profit (provided he is observant and alert) from actual firefighting experience and from observing the work of his fellow firefighters in action.

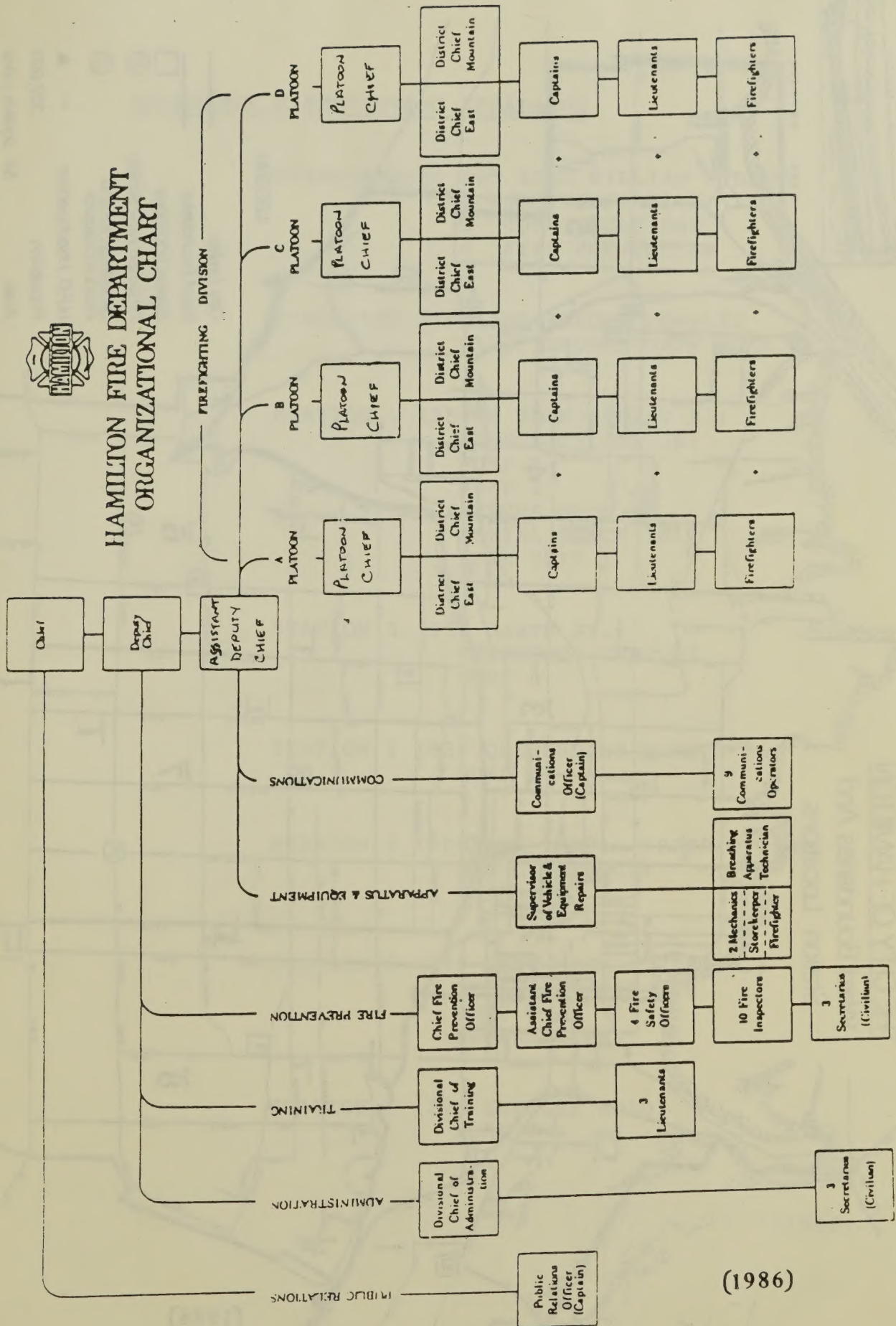
Fire in Hamilton can be controlled only while good leadership is combined with loyal and well-trained personnel. The probationary firefighter who is ambitious, honest and loyal; who takes pride in his job and in his department; and who trains and studies diligently to master the vast store of firefighting knowledge available to him, will become a good firefighter and a successful one, a capable leader and a credit to the department.

HIS FUTURE DEPENDS UPON HIMSELF!

(1986)



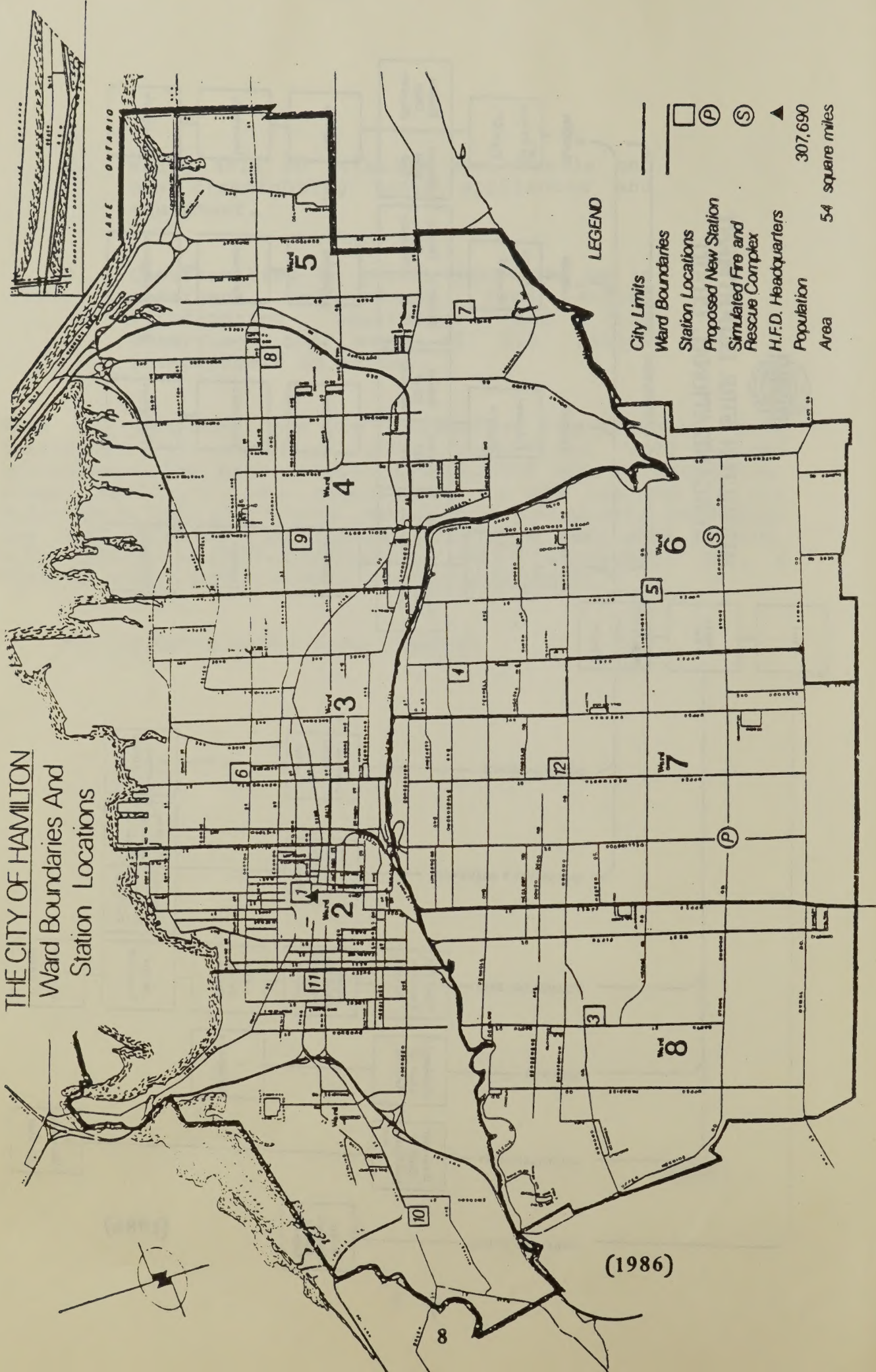
HAMILTON FIRE DEPARTMENT ORGANIZATIONAL CHART



(1986)

THE CITY OF HAMILTON

Ward Boundaries And Station Locations



LEGEND

- City Limits
- Ward Boundaries
- Station Locations
- Proposed New Station
- Simulated Fire and Rescue Complex
- H.F.D. Headquarters
- Population 307,690
- Area 54 square miles

(1986)

2. EMERGENCY FIREFIGHTING APPARATUS

HEADQUARTERS (55 KING WILLIAM STREET)

- o ADMINISTRATION
- o COMMUNICATIONS
- o FIRE PREVENTION

SIMULATED FIRE AND RESCUE COMPLEX
(1227 STONECHURCH ROAD EAST)

STATION 1 (35-43 JOHN STREET N.)

EMERGENCY CAR 201
PUMP 1
PUMP 2
RESCUE UNIT 1
AERIAL TRUCK 101
FOAM UNIT 1

STATION 3 (965 GARTH ST.)

EMERGENCY CAR 203
PUMP 3

STATION 4 (930 QUEENSDALE AVENUE E.)

PUMP 4

STATION 5 (OPENING 1987) (UPPER OTTAWA
AND LIMERIDGE)

PUMP #5

STATION 6 (246 WENTWORTH STREET N.)

EMERGENCY CAR 206
PUMP 6
SNORKEL 106

STATION 7 (225 QUIGLEY ROAD)

PUMP 7

(1986)

STATION 8 (400 MELVIN AVENUE)

PUMP 8

TANKER 8

STATION 9 (125 KENILWORTH AVENUE NORTH)

EMERGENCY CAR 209

PUMP 9

RESCUE UNIT 9

AERIAL TRUCK 109

STATION 10 (1455 MAIN STREET W.)

PUMP 10

STATION 11 (24 RAY STREET S.)

PUMP 11

AERIAL TRUCK 111

STATION 12 (779 UPPER WENTWORTH ST.)

EMERGENCY UNIT 12

AERIAL TRUCK 112

(1986)

3. HAMILTON FIRE DEPARTMENT DISPATCH CODES

- 5 - 0 - Code Green - 1 piece of apparatus.
 - non-emergency response
 - no emergency flashers or siren.
- 5 - 0 - 1 piece of apparatus - car/Rescue Unit, pump or truck
- 5 - 1 - 2 pieces of apparatus, car/Rescue Unit and a pump. a 5 - 1 response could also consist of a car, a pump, and aerial truck. (Example: Smell of smoke).
- 5 - 2 - Senior officer, two pumps, one aerial truck, car/Rescue Unit.
- 5 - 3 - ADDITIONAL - Senior Officer, 2 Pumps, 1 Aerial Truck (Rescue Unit if not dispatched on original 5 - 2). The Chief, Deputy Chief, Executive Officer, Communications Officer, Division Chief of Training, Public Relations Officer, Supervisor of Apparatus (Notified of 5 - 3 alarm in progress and respond).
- 5 - 4 - ADDITIONAL - 2 off duty Senior Officers, 2 Pumps, 1 Aerial Truck.
- 5 - 5 - ADDITIONAL - 2 Pumps, 1 Aerial Truck.
- 5 - 6 - General Alarm

NOTE: Alarm Dispatches can vary under special conditions:

Example - Tanker #8 poor water supply
- Foam Unit #1 - Hazardous material incident.

(1986)

4. GOVERNING LAWS, ACTS, RULES AND REGULATIONS

The Hamilton Fire is governed by the following:

- a) Department Policy and Procedures
- b) Occupational Health and Safety Act.
- c) By-Law 68 - 34.
- d) Fire Marshal's Act
- e) Fire Department Act
- f) Emergency Measures By-Law, R 85 - 103
- g) Working Agreement

NOTE: FOR ADDITIONAL INFORMATION, REFER TO I.F.S.T.A.
MANUAL.

(1986)

CHAPTER 2

ROPES

FIRE SERVICE KNOTS AND THEIR APPLICATION

1. INTRODUCTION

Firefighters must not only learn to tie knots, but they must learn them well enough to be able to tie any knot automatically or in complete darkness. Practice is essential and is each Firefighter's personal responsibility.

Your knot, improperly tied, may kill a fellow firefighter, a casualty you are rescuing, or maybe suicide for yourself.

2. GENERAL CLASSIFICATION OF ROPE

- a) Natural Fibre Rope
- b) Synthetic Fibre Rope

3. TYPES OF ROPE CARRIED ON HAMILTON FIRE DEPARTMENT

- i) MANILA (NATURAL)

It is flexible and has a natural resistance to wind, rain and sun.

(1986)

SPECIFICATIONS

SIZE		DESCRIPTION	TENSILE STRENGTH (BREAKING STRENGTH) (kg)	SAFE WORKING STRENGTH		BREAKING STRENGTH
Actual (mm)	Estimate (mm)			New (kg)	Used After 6 Mths Service (kg)	
9.5	10.0	Handline	612	123	61	Multiply the safe working strength of rope by 5.
19.05	20.0	General use for tying and hoist- ing equipment	2449	490	245	

a) CARE OF MANILA ROPE

- New rope should be stretched slightly before use, to take out stiffness.
- Rope should be stored in a well ventilated place. Never on concrete floor. It should be on a wooden platform to allow ventilation.
- Rubbing rope on sharp edges will wear the fibres through and weaken the rope.
- Dragging rope over ground may break or cut the fibres and lower the tensile strength.
- Rope should be uncoiled correctly, so as not to separate strands.
- Rope should be carefully dried after use around water, to prevent rotting.

(1986)

- Sharp bends or kinks should be avoided as they damage the fibres. Proper knotting methods will help prolong the life of the rope. When fibres break, strain is placed on the remaining fibres and this reduces the breaking strength of the rope.
- Coiling should always be done in a clockwise motion as all commonly used ropes have a right hand lay. This will prevent kinking.
- Jerk loads should never be put on a rope. The strength of the rope depends on the friction of the fibres against each other, and if the load is applied suddenly, there is great danger of the rope parting.

b) INSPECTION OF MANILA ROPE

- Rope should be inspected periodically (depending on how much use it gets, strain that has been put on it, proper storage, etc.), to determine whether any fault may have developed either on the surface or internally. In view of the numerous conditions that may affect the strength of rope and the fact that only part of the rope may be affected, it shall be examined throughout its entire length, on the surface and internally.
- The important conditions to look for internally are:
 1. Broken Fibres.
 2. Fine powder which determines the presence of grit.
 3. Mildew or mold.
 4. Change of colour of the fibres.

(1986)

3. TYPES OF ROPE CARRIED ON HAMILTON FIRE DEPARTMENT

ii) KERNMANTLE NYLON RESCUE ROPE (SYNTHETIC)

Static kernmantle is the finest rope made for raising and lowering human life under the most severe conditions imaginable.

Construction is of kernmantle design (braided sheath with a special, continuously stranded core) which has proven to be of unrivalled strength and features low stretch, high heat and abrasion resistance and easy handling with a no-spin kink feature.

ABRASION:

This rescue rope is an all monofilament nylon rope built in the kernmantle style, which protects the internal core from damage, contamination and wear. The sheath is comprised of a double ply of fibres and accounts for only 25 percent of the rope's strength. The core, because it is oriented parallel with the lines of force applied to it, carries 75 percent of the tensile strength. What this means is the sheath can almost be destroyed and the rope will only lose 25 percent of its strength.

STRETCH:

One of the biggest drawbacks of using nylon rope is that it stretches. This rescue rope has, through a unique design, been able to control stretch to less than 1.5 percent.

(1986)

HANDLING:

This rescue rope is also pliable enough to be tied, rigged and stored easily.

STANDARD FEATURES:

a) MATERIAL -

100 percent Dupont nylon (non-filament) for sheath and core.

b) SHEATH - (Comprises approximately 25 percent of strength)

Double jacket, one over, one under for ultra high abrasion resistance. Sheath will not slide on core as will other braid on double braid and kernmantle ropes. Sheath is coloured, not dyed, a different colour from core for safety inspections at a glance.

c) TEMPERATURE RESISTANCE

Maintains properties and strength to 176.5°C.

Melting point, 248.8°C.

d) ABRASION RESISTANCE

Three times more resistant than lay rope, braid and double braid constructions. Offers the highest abrasion resistance of any rope made. The braided sheath or jacket protects over 50 percent of the total nylon fibers in the rope from abrasion and cutting.

(1986)

For example, the fall factor equals one when a 10 metre fall occurs with 10 metres of rope in service: $10/10 = 1$. Note that the fall factor for a 10 metre fall with 10 metre of rope in service is the same as a 100 metre fall with 100 metres of rope in service. Both yield a fall factor of one and present the same stress to the rope. A factor-two fall is the most severe fall and occurs when a climber falls from above his belayer. For example, the fall factor equals two when a 20 metre fall occurs with 10 metre of rope in service: $20/10 = 2$. A factor-two fall is twice as severe as a factor-one fall. Whenever possible, factor-two falls should be avoided by proper planning and rope handling since they present an extremely severe dynamic load to a rope, which could cause it to break. Most falls that occur during fire service operations are of factor-one or less in severity.

Another factor that must be considered when evaluating fall arrest is the force transferred to the person(s) falling. The rope must act as a shock absorber and absorb the energy developed by the fall thus minimizing the force applied to the person(s) falling. This dynamic load is called the "impact force" by mountain climbers and can be determined for specific ropes and loads only by laboratory testing. However, in general, the greater the rope's elongation, the lower the impact force transferred to the person(s) falling.

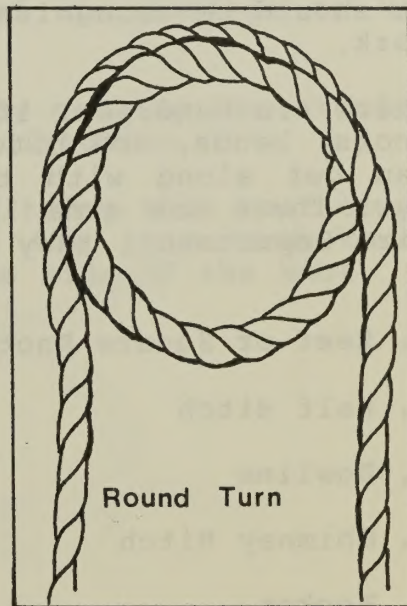
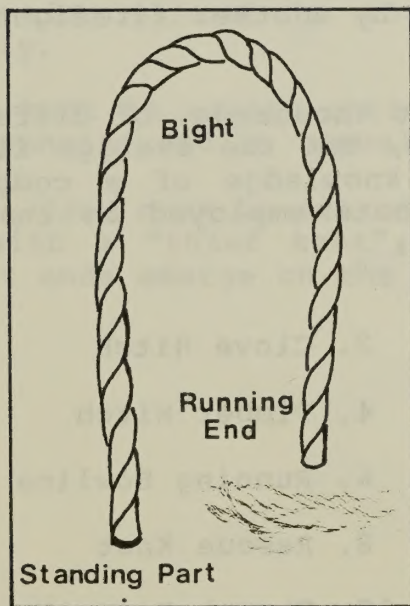
4. ROPE TERMINOLOGY

It is necessary for the student to understand the different parts of the rope in knot tying as the instructor refers to them. Standard methods make teaching and learning easier.

- a) Standing Part - is that part of the rope which is not used in tying the knot (the inactive part).
- b) Running End - is that part of the rope bent around the standing part in tying a knot.

(1986)

- c) Bight - is formed by bending the rope and keeping the sides parallel.
- d) Round Turn - is the action of looping the running part of a rope over an object, or over the standing part.



5. KNOTS, BENDS AND HITCHES

In order to be usable, a knot should:

- a) Serve the purpose required.
- b) It should be possible to tie and untie in the dark.
- c) It should be recognizable by another firefighter in the dark.

There are hundreds, if not thousands, of different rope knots, bends, and hitches, but the average firefighter can get along with the knowledge of a comparatively few. There are some 10 knots employed on the Hamilton Fire Department, they are:

- | | |
|------------------------|-----------------------|
| 1. Reef or Square Knot | 2. Clove Hitch |
| 3. Half Hitch | 4. Timber Hitch |
| 5. Bowline | 6. Running Bowline |
| 7. Chimney Hitch | 8. Rescue Knot |
| 9. Becket | 10. Church Raise Knot |

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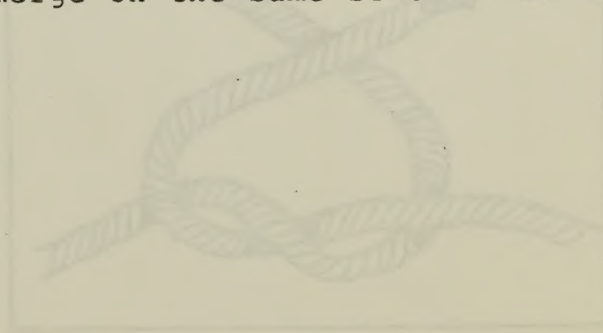
THEIR USES:

1. Reef or Square Knot

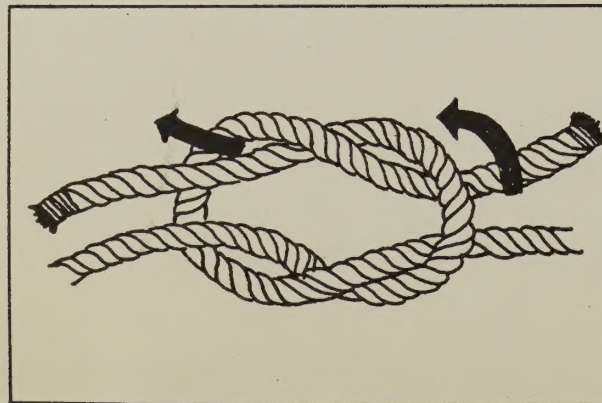
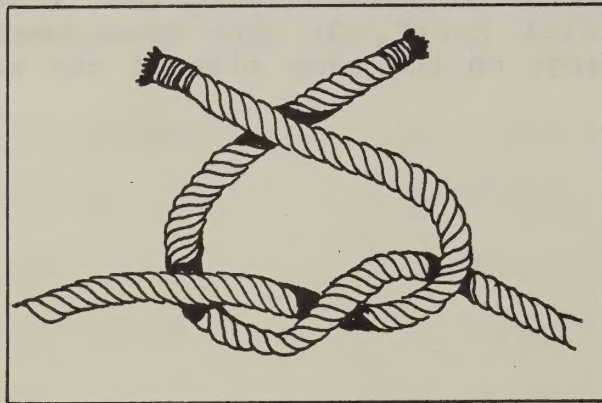
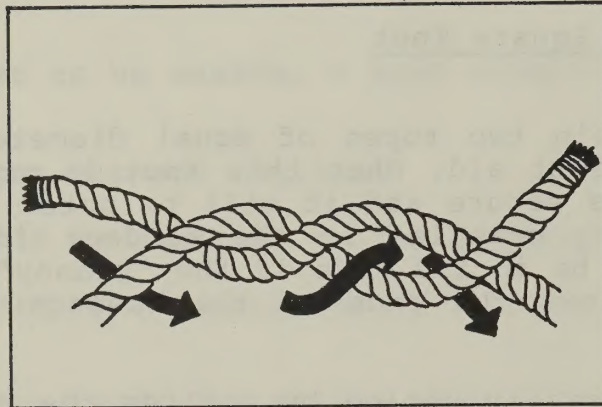
Is used to join two ropes of equal diameter and for tying bandages in first aid. When this knot is properly tied on a bandage, it is secure and it will be noted that the running ends are lying parallel to the bandage instead of across them as would be in the case if the "granny" knot were used. This also allows the ends of the bandage to be tucked in easily.

This knot is easily untied by pulling the standing part and one running end in opposite direction.

Note: Care must be exercised tying this knot or you will end up with a "thief knot". In the true Reef knot, both the short ends emerge on the same side of the knot.



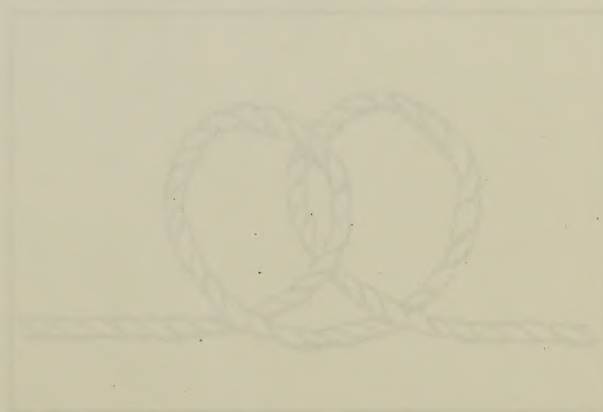
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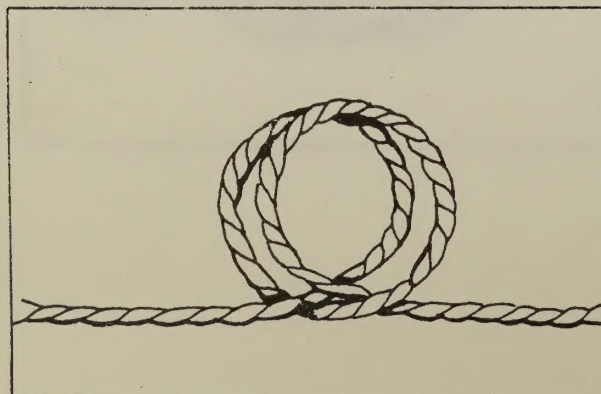
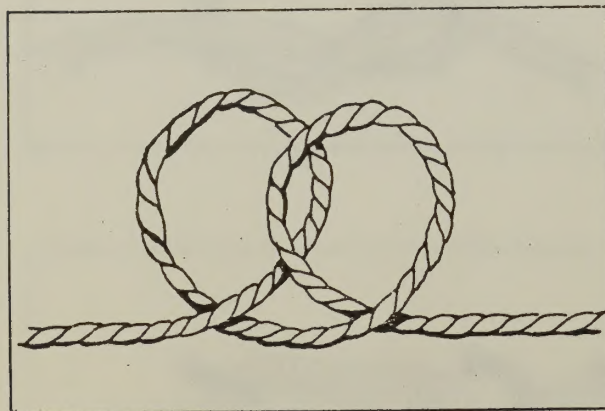
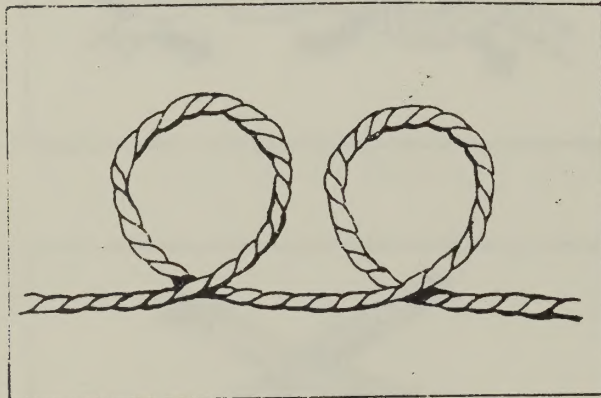
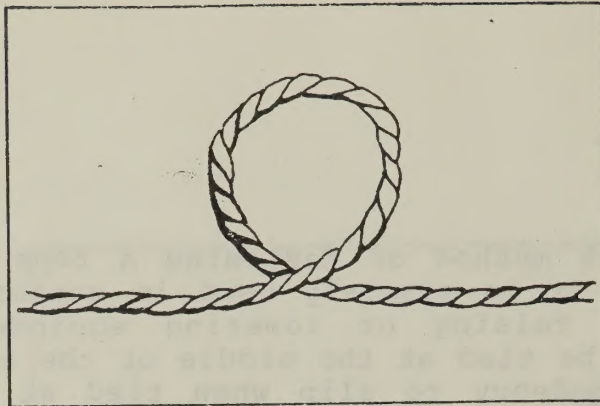
(1986)

2. Clove Hitch:

This is a quick method of fastening a rope around a post, stake or beam. It is commonly used in conjunction with the half hitch in raising or lowering equipment to various levels. It can be tied at the middle or the end of the rope. As it has a tendency to slip when tied at the end of the rope, the end should be half-hitched to the standing part for greater security.



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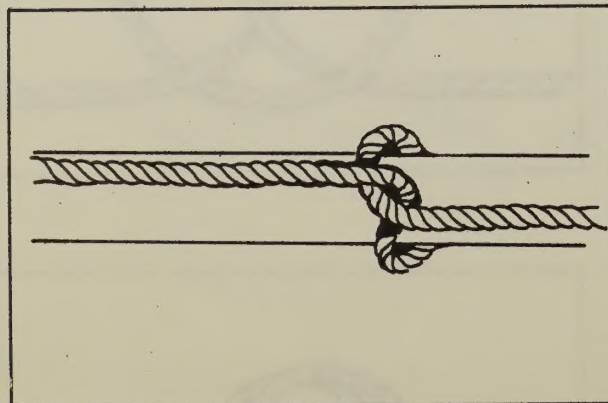
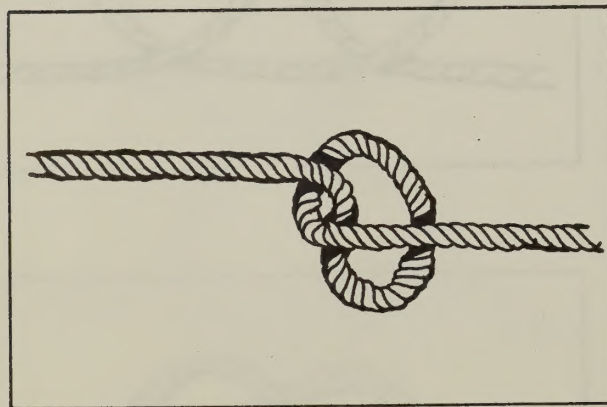
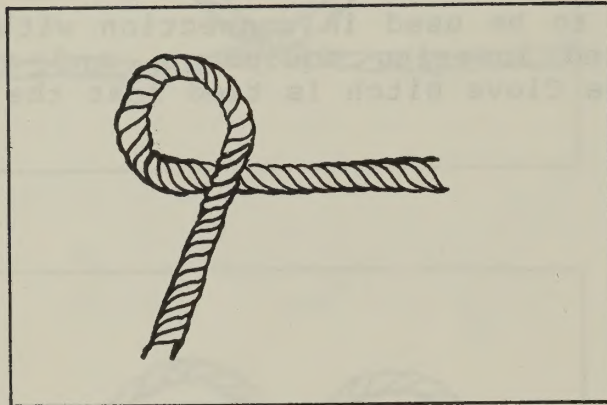


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3. Half Hitch:

This knot is to be used in connection with the Clove Hitch in raising and lowering equipment, and also as a safety hitch when the Clove Hitch is tied near the end of the line.

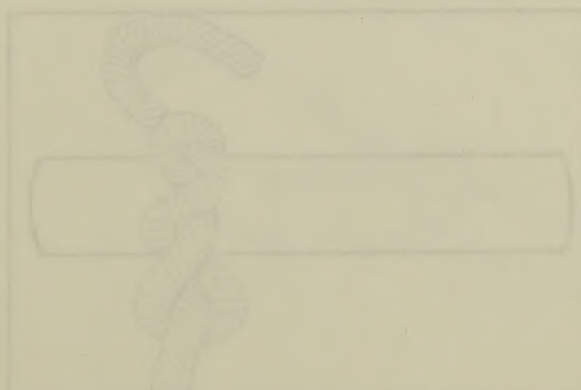
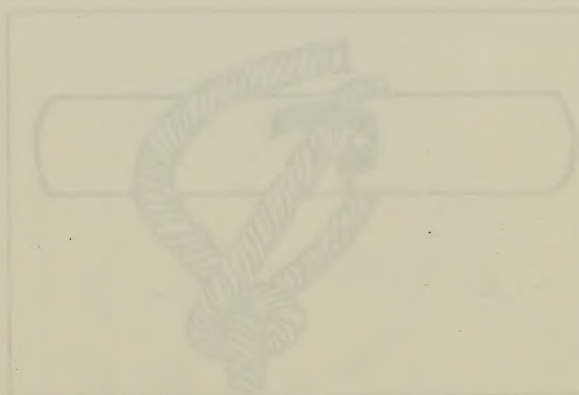
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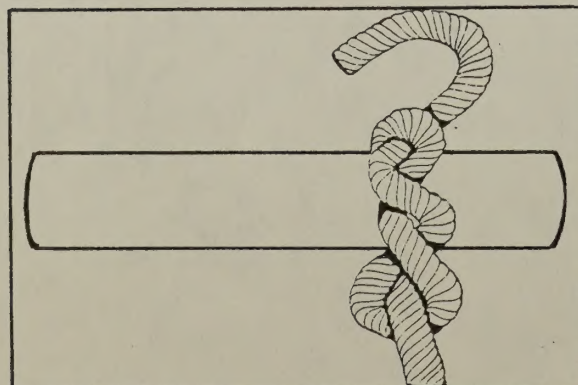
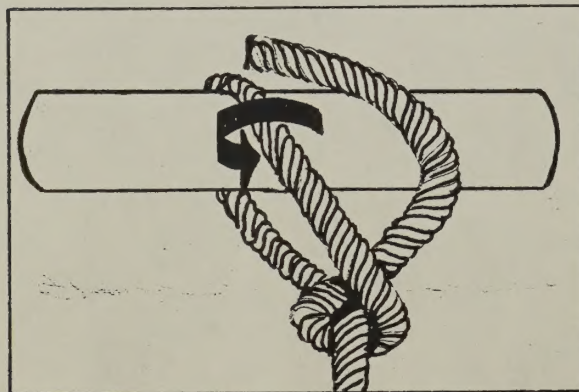
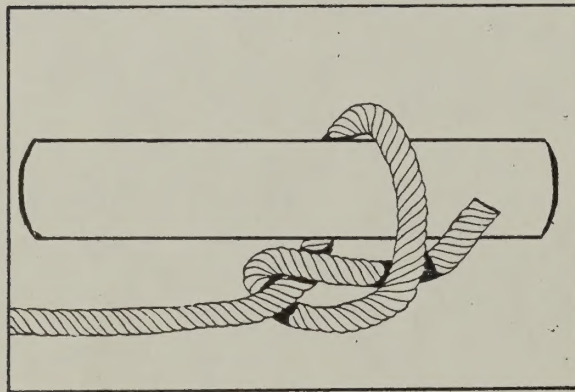
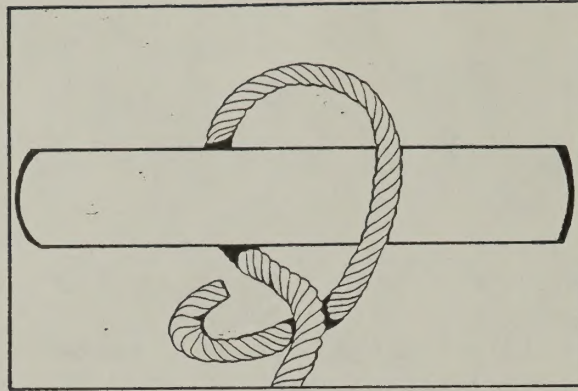
(1986)

4. Timber Hitch:

This is a quickly made temporary knot used to secure a rope to any object such as a pole, etc. It can also be used to raise tarpaulins. When lifting an object, this hitch should be used in conjunction with a half hitch at the upper end of the object being raised.



(1986)



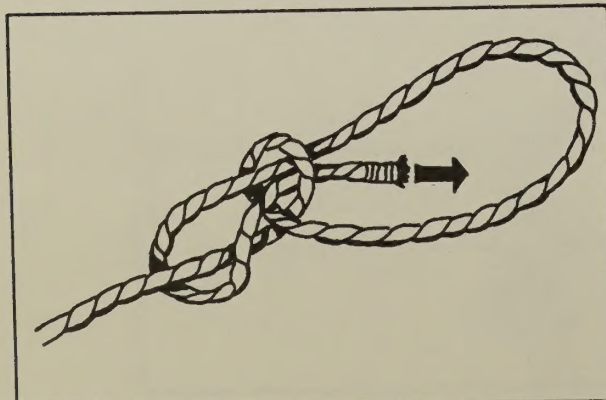
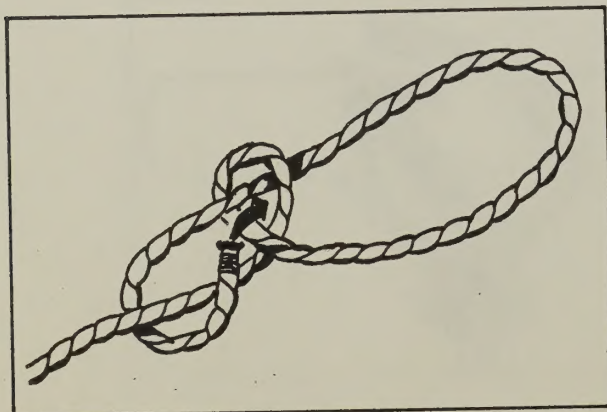
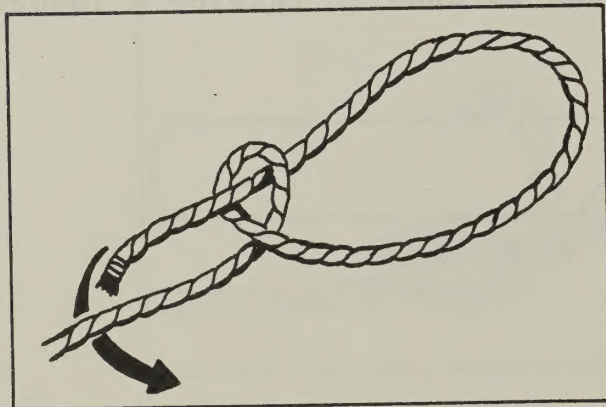
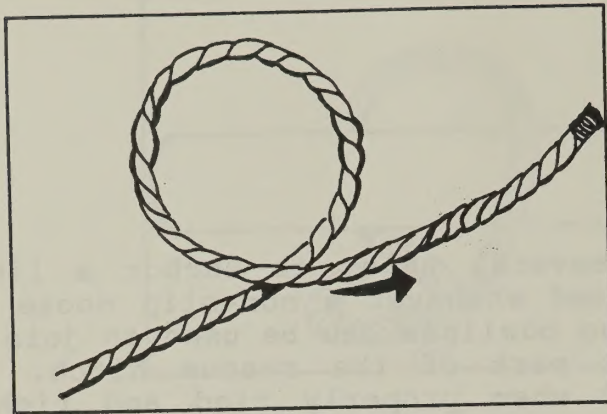
(1986)

5. Bowline:

This knot has several uses: to anchor a line to a solid object, to be used whenever a non-slip noose is called for -two interlocking bowlines can be used to join two ropes -it is an important part of the rescue hitch. It is a very secure knot and when properly tied and tightened, cannot slip or come apart. It is to be used as a loop when raising axes, sledges, shovels, etc., in conjunction with the Half Hitch. It may also be used in raising a ladder to heights.



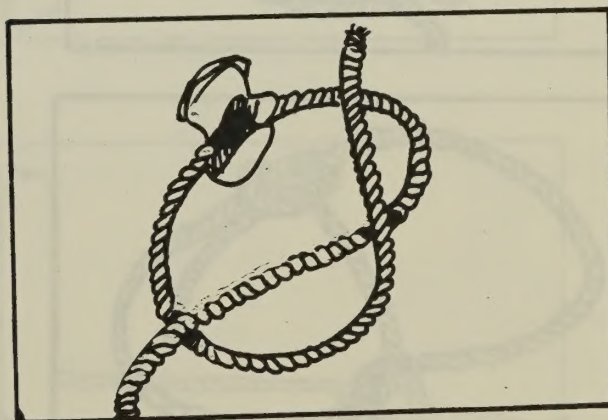
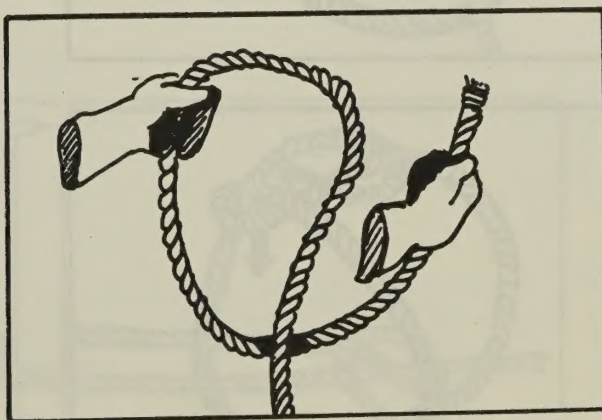
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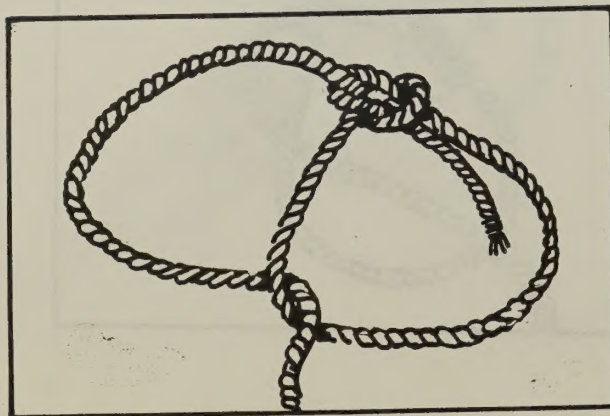
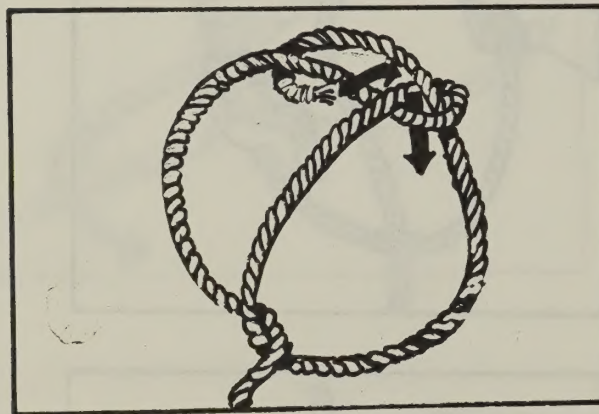
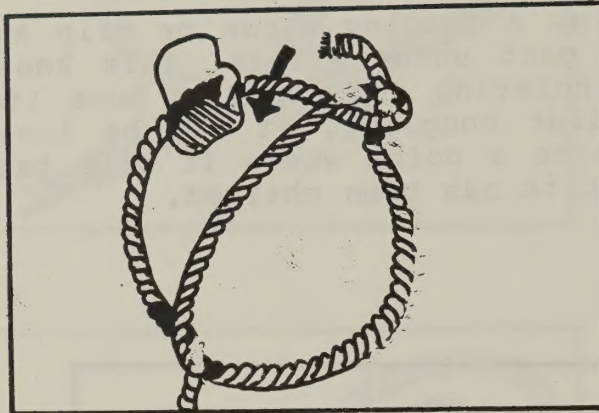
(1986)

6. Running Bowline:

This is used as a sliding noose or slip knot. It is secure and will not part under strain. This knot may be used to advantage in hoisting and securing hose lines. When applied behind the first coupling, it can be loosened and slipped down the hose to a point where it will take the strain off the line after it has been charged.



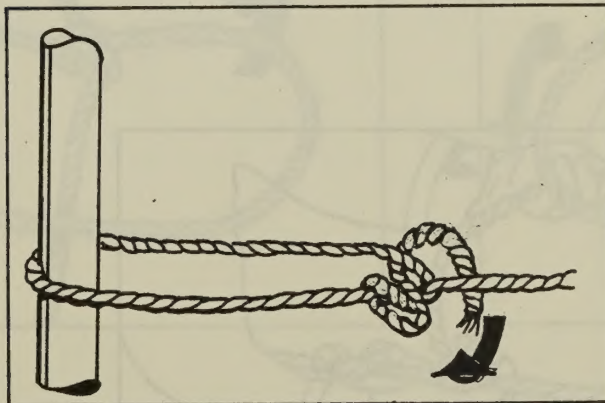
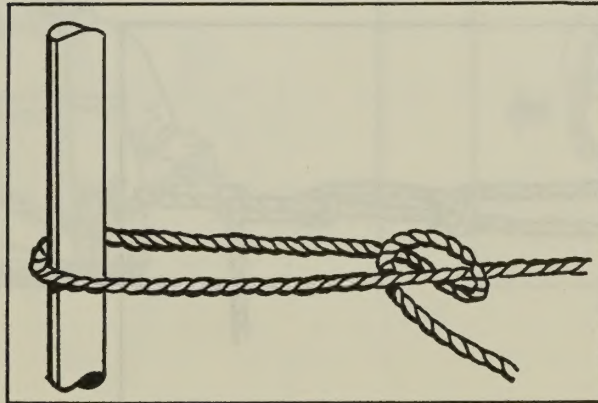
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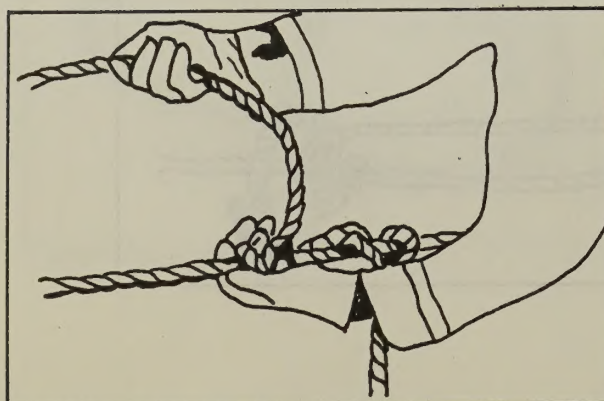
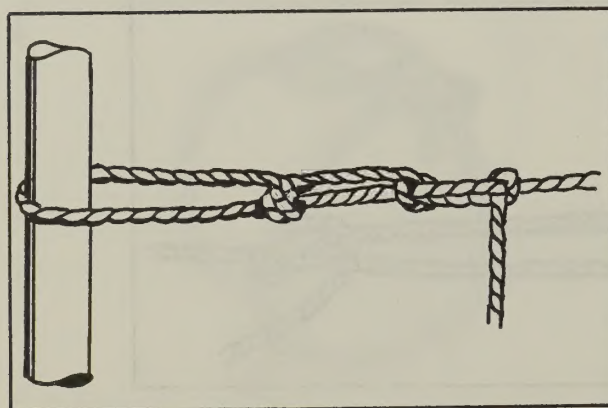
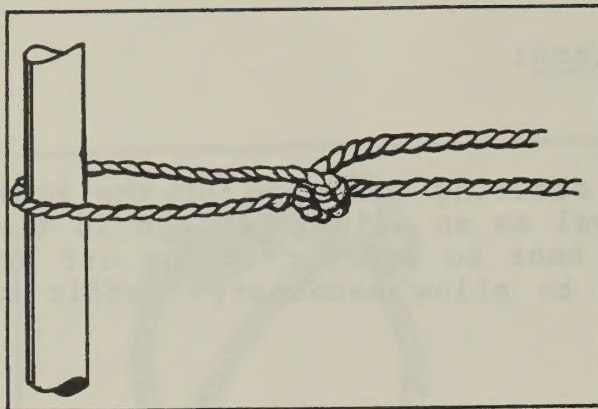
(1986)

7. Chimney Hitch:

To be used in securing the rope of the hose roller on the roof. It is ideal as an adjustable eye in the end of a rope. It is an ideal knot to use for roping off areas as the knot can be slipped to allow necessary traffic movement without untying it.



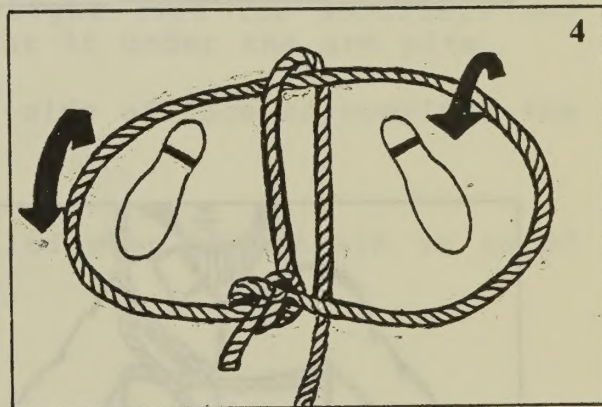
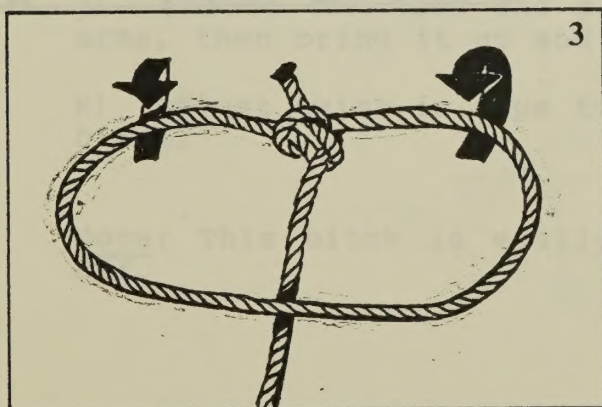
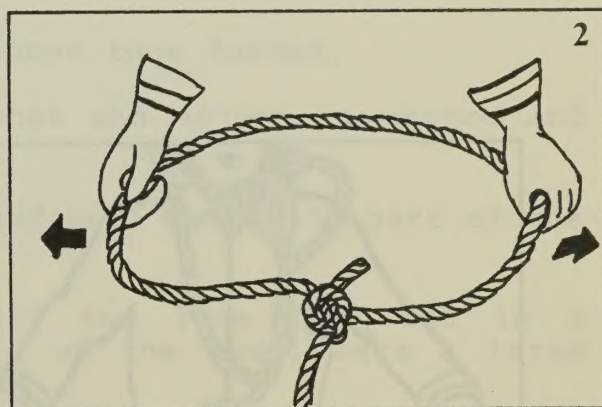
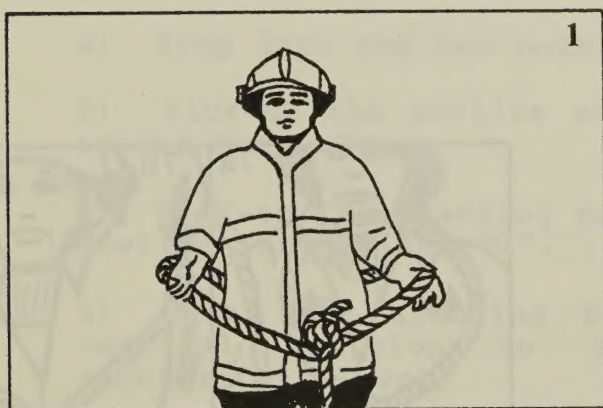
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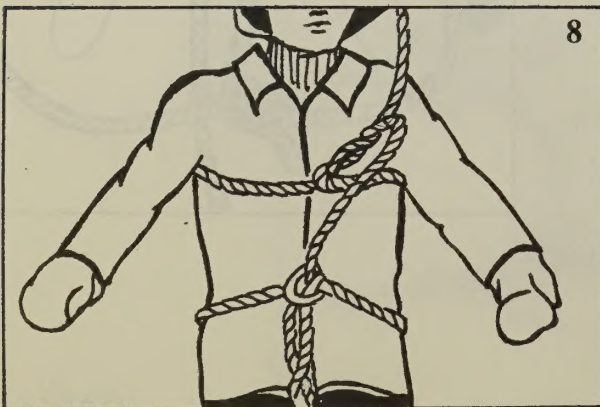
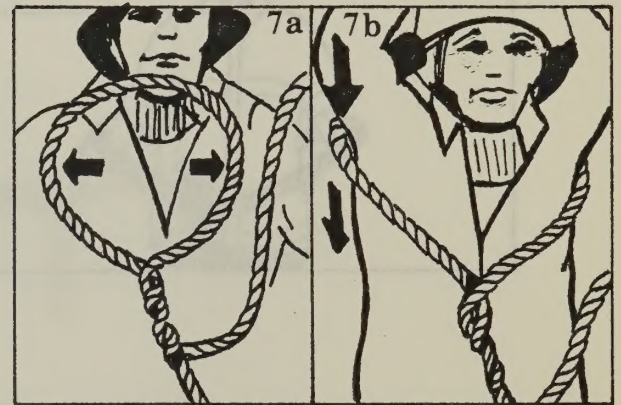
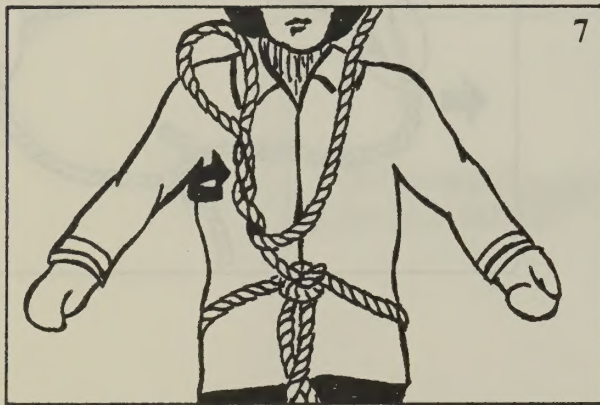
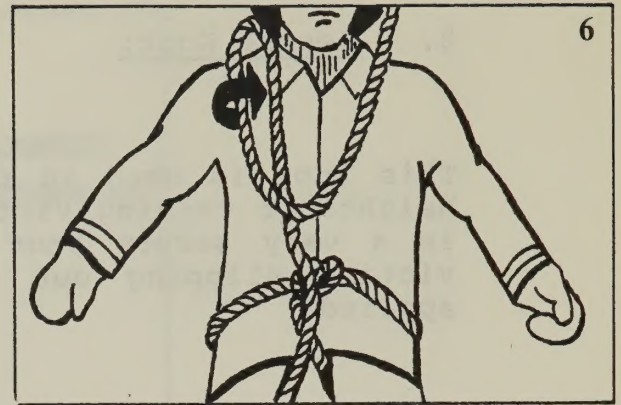
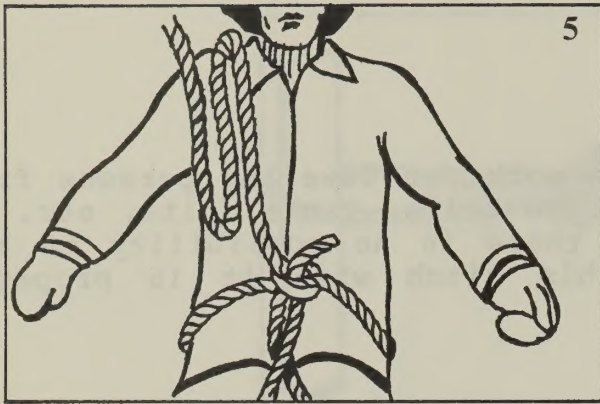
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8. Rescue Knot:

This knot is used in rescue work for lowering persons from heights or raising victims from wells, tanks, pits, etc. It is a very secure knot and there is no possibility of the victims slipping out of this hitch when it is properly applied.



(1986)



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Steps in Tying the Rescue Hitch:

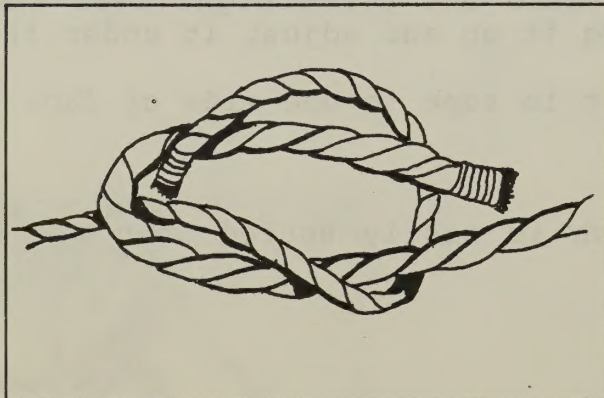
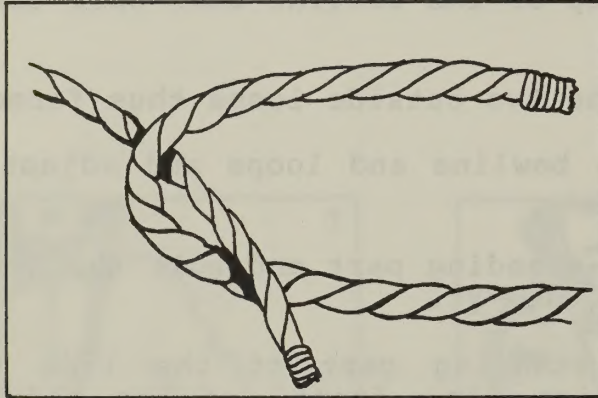
- a) Make a bowline by passing the rope around the buttocks and tying a knot at arms length, in front of you.
- b) Place bowline on the ground, with the standing part lying straight away.
- c) Pick-up the loop of the bowline in both hands near the centre on each side and slightly stretch it.
- d) Turn the loop of the bowline back onto the standing part twice.
- e) Step into the two outside loops thus formed.
- f) Pick-up the bowline and loops and adjust in crotch and around buttocks.
- g) Pick-up the standing part and pull the hitch part of the bowline through the "V".
- h) With the standing part of the line taut and in a vertical position in front of the body, make a large bight at eye level.
- i) Twist this bight in either direction so that there are three or more full twists in the rope.
- j) Insert the head and place bight over the shoulders and arms, then bring it up and adjust it under the arm pits.
- k) Adjust twist in rope to one side of face to complete the hitch.

Note: This hitch is easily untied when the strain is eased off.

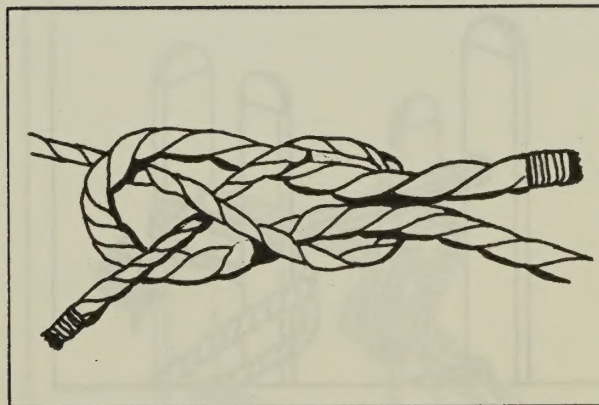
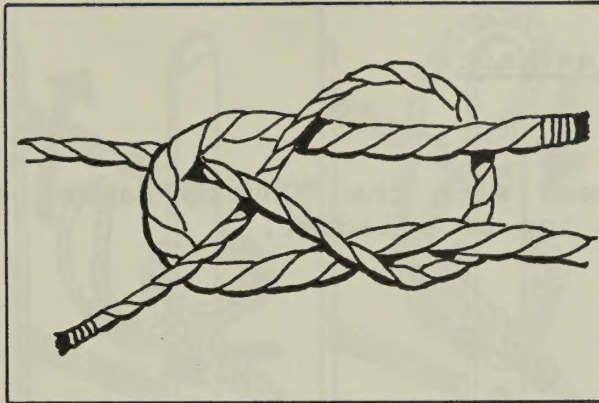
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9. Becket or Sheet Bend:

To be used to temporarily join two ropes of equal or different diameters.



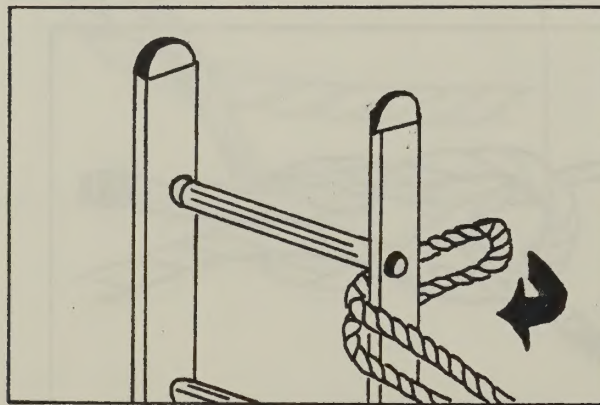
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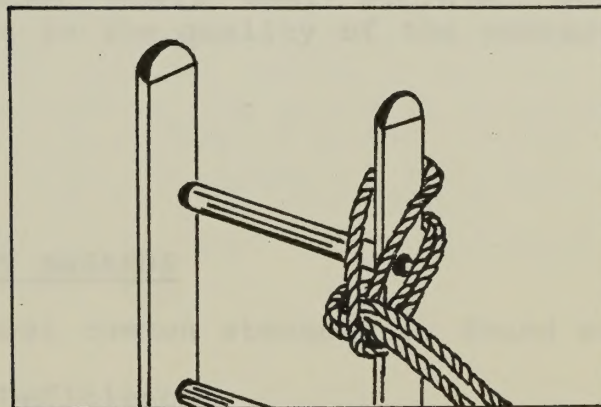
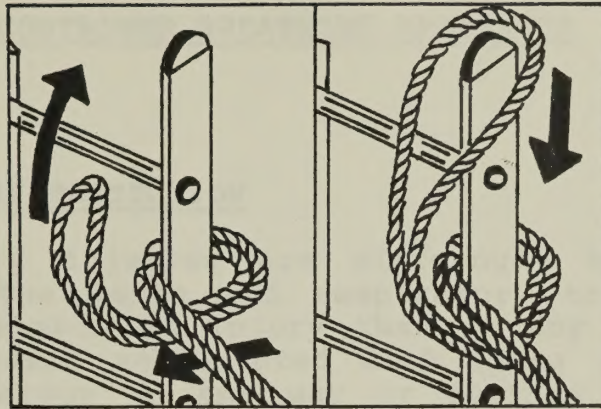
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10. Church Raise Knot:

This knot is used with the "Church Raise" and to secure a guy rope to the top of a ladder.



(1986)



NOTE: FOR ADDITIONAL INFORMATION, REFER TO I.F.S.T.A. MANUAL

(1986)



NOTE FOR ADDITIONAL INFORMATION, REFER TO U.S.A. 11

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CHAPTER 3

SELF-CONTAINED BREATHING APPARATUS

INTRODUCTION

1. RESPIRATORY PROTECTION

Respiratory injuries are alarmingly high in the fire service. The lungs and respiratory tract are probably more vulnerable to injury than is any other body area, and the gases encountered with fires are for the most part dangerous in one way or another. It should be a fundamental rule in fire fighting that no firefighter be permitted to enter a building that is charged with smoke or gas unless the firefighter is equipped with self-contained breathing apparatus. The Hamilton Fire Department Breathing Apparatus policy 31-0 states that all personnel shall wear S.C.B.A. when there is any question as to the quality of the atmosphere.

2. RESPIRATORY HAZARDS

The four most common atmospheres found at fires:

- a) Oxygen Deficiency
- b) Elevated Temperatures
- c) Smoke
- d) Toxic Gases

- a) Oxygen Deficiency

The combustion process consumes oxygen while producing toxic gases that either physically displace oxygen or dilute its concentration. When oxygen concentrations are below 18%, the human body responds by increasing the respiratory rate.

b) Elevated Temperatures

Exposure to heated air can damage the respiratory tract, and if the air is moist, the damage can be much worse. Excessive heat, temperatures exceeding 49°C, taken quickly enough into the lungs can cause a serious decrease in blood pressure and failure of the circulatory system. Inhaling heated gases can cause edema (fluid collection) in the lungs, which can cause death from asphyxiation. The tissue damage from inhaling hot air is not immediately reversible by introducing fresh, cool air.

c) Smoke

Most of the smoke at a fire is a suspension of small particles of carbon and tar, but there is also some ordinary dust floating in a combination of heated gases. The particles provide a means for the condensation of some of the gaseous products of combustion, especially aldehydes and organic acids formed from carbon. Some of the suspended particles in smoke are merely irritating, but others may be lethal. The size of the particle will determine how deeply into the unprotected lungs they will be inhaled.

d) Fire-Related Toxic Gases

The firefighter should remember that a fire means exposure to combinations of the irritants and toxicants that cannot be predicted accurately beforehand. In fact, the combination can have a synergistic effect in which the combined effect of two or more substances is more toxic or more irritating than the total effect would be if each were inhaled separately.

Inhaled toxic gases may have several harmful effects on the human body. Some of the gases directly cause disease of the lung tissue and impair its function. Other gases have no directly harmful effect on the lungs but pass into the bloodstream and to other parts of the body and impair the oxygen-carrying of the red blood cells.

(1986)

A Special Note on Carbon Monoxide:

- colorless, odourless gas
- a common asphyxiate (More fire deaths occur from carbon monoxide than from any other toxic product of combustion).
- absorbed into bloodstream 240 times faster than oxygen therefore, a danger even if ample oxygen available.
- in a 1% C.O. atmosphere, death can occur after 3 minutes of exposure, whether breathed in one 3 minute or three one minute durations. The effect is cumulative.

Toxic Atmospheres Not Associated With Fire

Hazardous atmospheres can be found in numerous situations in which fire is not involved.

Examples are:

- a) industrial processes use extremely dangerous chemicals.
- b) refrigerants - ammonia, sulfur dioxide
- c) chlorine gas
- d) rescues in sewers, caves, trenches, storage tanks, tank cars, etc.

Toxic Materials enter the Body in 3 Ways:

- 1) Lungs- this is the most direct route causing the most devastating effects.

They are affected by:

- a) oxygen deficiency - hypoxia - it can be gradual or immediate depending on oxygen concentration.
- b) airborne contaminants - can be particle matter, gases, or vapours.
- c) Heat - when conducted to lungs fast enough causes rapid blood vessel collapse.

(1986)

2) Digestive system - causing irritation, nausea or vomiting.

3) Skin - irritated by alkaline and acidic substances - will absorb many toxic gases and vapors which will eventually enter the blood stream - protective clothing must be worn in presence of: Hydrogen Cyanide, Concentrated Ammonia, Hydrocyanic Acid Gas (ACN), Benzene, phenol and tetraethyl lead (gas additive) etc.

- linings of mouth, nose and eyes, particularly sensitive.

3. TYPES

Self-contained breathing apparatus may be divided into two general categories:

1. open circuit - breath is vented to the open air

EXAMPLE: SCOTT PRESUR-PAK IIA

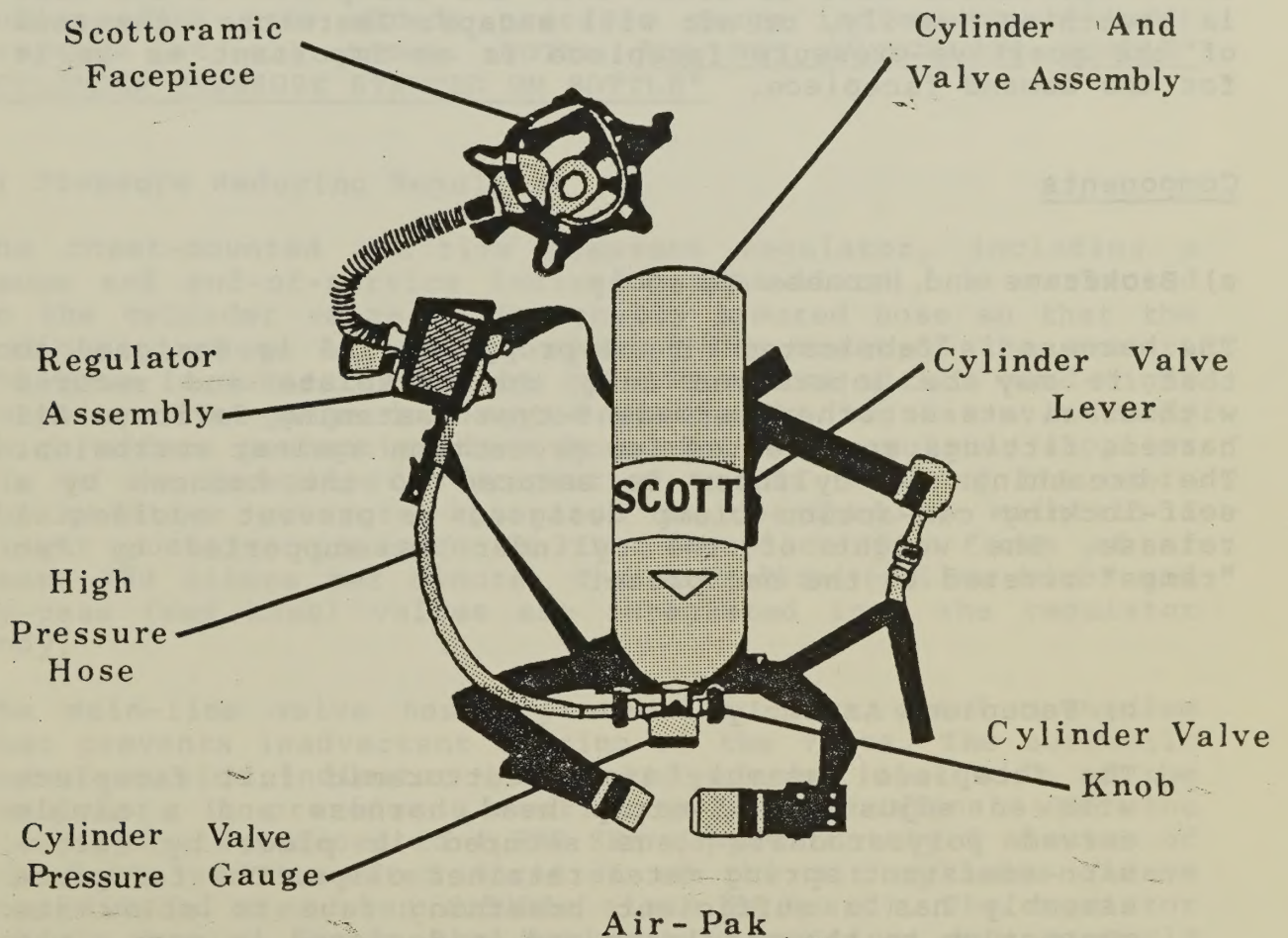
2. closed circuit - breath stays within the system for reuse.

EXAMPLE: DRAGER

(1986)

PRESUR-PAK I Ia

Why is this Scott Presur-Pak called I Ia? The "II" stands for "demand" when the switch on the regulator is in the down or off position for donning or removing. The "a" stands for "positive pressure" when the switch on the regulator is in the up or on position. The Hamilton Fire Department uses the Presur-Pak in the "a" position when it is being used (switch in up position on regulator).



Open-Circuit Positive-Pressure Apparatus (Scott
Presur-Pak I Ia)

(1986)

Most positive-pressure units look almost exactly like the standard units. The cylinder and backpack assemblies are similar. The major difference is that in the positive-pressure unit the diaphragm in the regulator is held open to create a slight pressure in the low-pressure hose and facepiece. This pressure is held in the facepiece by a spring-loaded exhalation valve so the pressure inside the facepiece is slightly higher than atmospheric pressure, preventing the entry of smoke particles and toxic gases. The insignificant amount of extra breathing air expended is well worth the extra safety to the user. If the seal of the facepiece against the face is not good, however, there is still the possibility that toxic substances will be drawn into the facepiece if the user is breathing heavily, or air will escape. Therefore, the seal of the positive-pressure facepiece is as important as it is for the demand facepiece.

Components

a) Backframe and Harness Assembly

The harness is fabricated of polypropylene and is designed so that it may be interwoven into the backplate and secured without rivets or other permanent-type fastening devices. All harness fittings are treated for protection against corrosion. The breathing air cylinder is secured to the harness by a self-locking cam-action clamp designed to prevent accidental release. The weight of the cylinder is supported by two "ramps" riveted to the backplate.

b) Facepiece Assembly

The facepiece assembly is a Scottoramic full facepiece with an adjustable 5-strap head harness and a single curved polycarbonate lens secured in place by corrosion-resistant spring metal retainer clips. The facepiece assembly has a sufficient breathing tube to allow its connection to the regulator and is designed in such a way to allow inhalation rates as high as 900 liters per minute without collapse. Airflow is directed across the lens, minimizing fogging.

Positive pressure facepieces have an additional assembly which is a pressure compensated (balanced) exhalation valve. The exhalation valve maintains positive facepiece pressure during use.

(1986)

c) Cylinder and Valve Assembly

The breathing air cylinder is constructed of aluminum. Fully charged, the aluminum flat top 30 minute rated cylinder contains 1,274 litres of breathing air at 15,200 KPa (2216 psi marked on bottle). The steel round top 30 minute rated cylinder contains 1,135 litres of breathing air at 13,893 KPa (2015 psi marked on bottle). The complete unit weighs more than 15 Kg. Aluminum and steel cylinders must be hydrostatically tested at least every 5 years, based on the most recent hydrostatic test date on the cylinder. Each cylinder valve is equipped with a spring-loaded positive action safety lock for "lock open service", disc safety relief device and a dual-reading (two sided) pressure gauge indicating cylinder pressure at all times. NOTE: "DO NOT OVERCHARGE BOTTLE"
"CYLINDER PRESSURE STAMPED ON BOTTLE"

d) Pressure Reducing Regulator

The chest-mounted positive pressure regulator, including a gauge and end-of-service indicator (Pak-Alarm), is connected to the cylinder valve by internally armored hose so that the indicating gauge is in full view on the chest of the wearer. The hose is connected to the cylinder valve with a hand-tight coupling. The gauge is mounted within the regulator assembly which offers protection from breakage. The regulator supplies air to the facepiece in proportion to the needs of the user. The positive pressure apparatus is designed to maintain a slight positive pressure in the facepiece for flows of at least 200 liters per minute. The main-line (yellow knob) and by-pass (red knob) valves are integrated into the regulator body.

The main-line valve has a protective "lock open" mechanism that prevents inadvertent closing of the valve. The automatic end-of-service indicator is mounted on the inlet side of the regulator. It provides a continuous audible signal when the air supply is reduced to 4,000 KPa (approximately 6 minutes of air left) of the rated duration of the air cylinder (leave contaminated area when audible alarm is heard). The regulator outlet opening is in the horizontal position when properly worn.

The regulator is a two-stage pressure reducing mechanism designed to reduce cylinder pressure to a safe breathable range. The first stage reduces cylinder pressure to approximately 213 KPa and supplies the reduced pressure to the demand valve (second stage).

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The high pressure reducing valve opens in the same direction as the flow of high pressure air. A relief valve is incorporated within the regulator so that any failure of the high pressure reducing valve will not impose excessive pressure on the demand valve. This 213 KPa is further reduced to breathable pressures by demand valve/diaphragm interaction.

Positive pressure regulators have an "ON-OFF" selector lever on the front cover for use during donning and doffing only. Positive pressure apparatus shall be used only with this lever in the "ON" position.

The regulator inlet incorpoates a fine mesh screen to exclude foreign matter from the breathing air supplied to the user. The hose connection at the regulator is a swivel joint.

FUNCTION OF APPARATUS COMPONENTS

Regulator Operation (See Figure 3-1)

Air at cylinder pressure enters the regulator at the inlet connector. Passage F leads to gauge A which indicates cylinder supply pressure. Air from passage F also flows through normally open MAIN-LINE valve at orifice E and through passage D to the first stage valve C. Valve C throttles high pressure air down to a lower pressure. Inside bellows chamber N, this lower pressure is maintained by spring loaded bellows assembly P. If pressure inside bellows chamber N tends to increase, the bellows expands, causing lever O to close first stage valve C. If chamber pressure tends to decrease, bellows assembly P contracts, causing lever O to release first stage valve C, allowing air to enter. Through this action, bellows chamber pressure is maintained at a constant preset pressure.

Low pressure air is conveyed through passage R to demand valve J. Operation of demand valve J is dependent upon movement of diaphragm K. When pressure in main chamber L is reduced by inhalation, diaphragm K is forced inward (toward the chamber) by ambient pressure acting on the outside of diaphragm K. This depression of the diaphragm tilts demand valve J, causing low pressure air to flow past the demand valve seat into main chamber L and out facepiece connection M to the user. When inhalation ceases, pressure inside the main chamber increases, causing the diaphragm to return to its original position. This permits the demand valve and first stage valve to close. During exhalation the regulator remains in this condition, ready to repeat the operation cycle at the next inhalation.

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Positive pressure regulators use a front cover which has a spring-loaded mechanism that deflects diaphragm K until a slight positive pressure is built up within main chamber L and closes demand valve J. In this manner, the spring maintains a positive pressure in main chamber L and facepiece.

Emergency Functions (See Figure 3-1)

During normal operation, MAIN-LINE valve (yellow knob) is fully open and locked while BY-PASS valve (red knob) is closed. In the event of regulator malfunction, BY-PASS valve provides an adjustable flow of air into main chamber L via passage B. If BY-PASS valve is needed, it should be opened first, then MAIN-LINE valve closed. BY-PASS valve may be adjusted to meter the amount of air required by the user while completely bypassing the regulator mechanism.

In the event that demand valve J should stick in the open position, orifice Q would limit the volume of air flow. Pressure build-up is prevented by facepiece exhalation valve and by outward leakage around facepiece periphery.

If pressure in passage R should exceed the preset level, relief valve G will protect regulator mechanism by discharging air into the main chamber. This flow of air provides a warning for conversion to by-pass operation and egress from the contaminated environment.

Pak-Alarm Operation (See Figure 3-1)

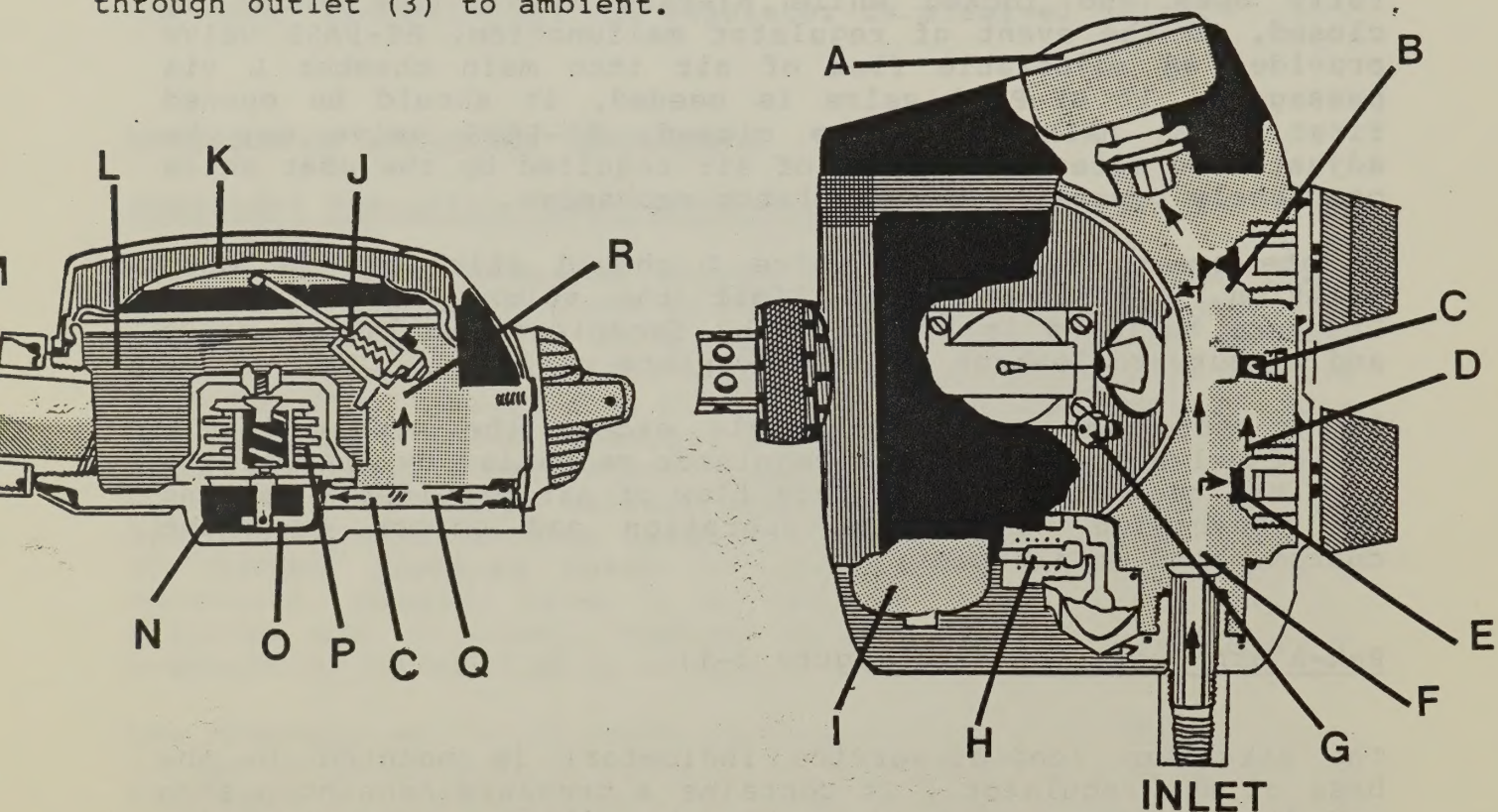
The Pak-Alarm (end-of-service indicator) is mounted in the base of the regulator. It contains a pressure-sensing piston and disc which actuates piston H. As cylinder pressure falls to approximately 4000 KPA, the pressure-sensing piston depresses the disc which allows air to flow to piston H which strikes bell I. As the piston strikes bell I, a small amount of air is allowed to escape. This action reduces pressure permitting spring to return piston to its original position. Pressure is then allowed to rapidly rebuild, causing continual ringing of the bell. This action will continue until cylinder pressure falls below 1400 KPA.

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FACEPIECE FUNCTION

Scottoramic facepieces have a flexible "flapper" exhalation valve, which is normally closed during inhalation. Inhalation causes regulator diaphragm K (figure 3-1) to open demand valve J, supplying air to the user.

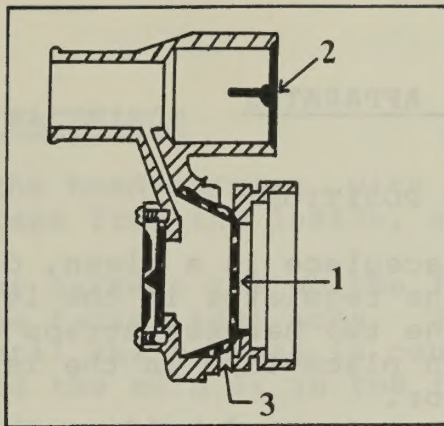
In addition, positive pressure facepieces have a balanced exhalation valve assembly (see figure 3-2). The diaphragm (1) senses mask pressure at inhalation and no flow. When exhalation begins, inlet check valve (2) closes, so that mask pressure is higher than that in the regulator and behind diaphragm (1). This allows air pressure from the mask to collapse diaphragm (1), thus allowing used air to "dump" through outlet (3) to ambient.



A	Pressure Gauge	K	Diaphragm
B	Passage	L	Main Chamber
C	First Stage Valve	M	Facepiece Connection (Regulator Outlet)
D	Air Passage	N	Bellows Chamber
E	Orifice	O	Lever
F	Air Passage	P	Bellows Assembly
G	Relief Valve	Q	Orifice
H	Piston	R	Passage
I	Bell		
J	Demand Valve		

Regulator Operation Figure 3-1

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Balanced Exhalation Valve Assembly Figure 3-2

5. DURATION OF AIR SUPPLY

"Expect no more than one minute per 700 KPa registered on the cylinder pressure gauge".

- 1) Factors that influence actual working time when wearing self-contained breathing apparatus are:
 - a) The physical condition of the user
 - b) The degree of physical exertion
 - c) The emotional stability of the user
 - d) The condition of the apparatus
 - e) The cylinder pressure before use
 - f) The amount of training and experience with breathing apparatus

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6. DONNING THE APPARATUS

a) FROM GROUND POSITION:

1. Place facepiece in a clean, dry area.
2. Grasp the regulator in the left hand.
3. Grasp the two harness straps with the right hand and then place them in the left hand with the regulator.
4. With the left hand holding the regulator and straps, lift the mask onto the left knee.
5. Turn the cylinder handwheel on full.
6. Check the pressure gauge is fully charged.
7. Grasp the harness at the regulator in the right hand.
8. Swing the left arm into the harness and grasp the cylinder.
9. Swing the right arm into the harness.
10. Fasten the chest strap and hoist the bottle up on your shoulders to a comfortable position (not too high).
11. Tighten the left and right cinch strap.
12. Fasten the waist strap.

b) JUMP SEAT POSITION

1. Mount apparatus and secure webbed safety gate.
2. While seated turn bottle on and check bottle pressure.
3. Place arms through harness and secure chest, cinch, and waist strap (check regulator pressure).
4. Keep holding bracket in locked position while vehicle is in motion.
5. Place facepiece over regulator or use securing device
DO NOT CONNECT TO REGULATOR.
6. Follow instructions in this chapter for donning the facepiece.

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7. DONNING THE FACEPIECE

1. Grasp the head harness, with the thumbs through the straps from the inside, and spread it.
2. Push the harness top up the forehead to brush hair from the facial seal area. Continue up and over the head until the harness is centred at the rear of the head and the chin is in the facepiece chin cup.

USING BOTH HANDS:

3. Tighten the bottom straps first by gripping the base of the facepiece, at the exhalation valve, with one hand and pulling the strap straight back using the other hand.

Using this technique, secure all other straps by alternately tightening the straps upwards and on both sides of the facepiece, until the top strap is reached and tightened with an even backwards pull.

4. Check the facepiece seal. Exhale deeply, seal the end of the low pressure hose with a hand, and inhale deeply and slowly. If there is evidence of leaking, adjust or redon the facepiece.
5. Check the exhalation valve. Inhale, seal the end of the low pressure hose, and exhale. If the exhalation does not pass through the exhalation valve, keep the low pressure hose sealed, press the sides of the facepiece against the face and temples, blow vigorously to free the valve.

NOTE: DO NOT CONNECT THE BREATHING TUBE to the regulator until ready to enter the contaminated area. This action helps to conserve the air supply. Tighten the quick-connect coupling firmly with the fingers. Position the switch on the side of the regulator in the "up" mode; Positive Pressure.

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8. REGULATION OF AIR FLOW TO FACEPIECE

1. Normal

- a) The emergency "by-pass" valve (red knob) is (fully) closed, in a clockwise position.
- b) The regulator mainline valve (yellow knob) is fully open in a counter clockwise position and locked using a lock tab.
- c) With the valves in the noted positions, air will flow to the facepiece automatically. With the pressure switch in the "on" position; Positive Pressure

2. Emergency - Where the positive pressure regulator becomes inoperative.

- a) Open the "by-pass" valve carefully (red knob).
- b) Close the mainline valve (yellow knob).
- c) Adjust the air flow to suit the requirements of the wearer.

NOTE: WHEN THE "BY-PASS VALVE HAS TO BE PUT IN OPERATION, THE WEARER SHOULD RETURN TO FRESH AIR AT ONCE. The air flowing to the facepiece is by-passing the timer gauge and there is no way to tell how much working time is left in the bottle.

9. CHANGING CYLINDERS (2 man, on back)

1. Get a full cylinder.
2. Return regulator switch to demand mode, down position.
3. Close valve assembly, release pressure from high pressure hose using by-pass valve.
4. Remove regulator hose from bottle valve.
5. Lower lever to release the bottle and remove.
6. Replace the bottle.
7. Lock the bottle in place, attach regulator hose and hand tighten coupling.
8. Open cylinder valve and check the gauges on the cylinder and the regulator.
9. Replace facepiece, test fit, put regulator switch in positive pressure mode before use.

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10. USE OF SELF CONTAINED BREATHING APPARATUS IN LOW TEMPERATURES

1. When leaving an extremely hot environment, such as a fire scene, and entering cold air (below or near freezing) always place the facepiece in a warm area. Eg. Cab of apparatus, inside turn out coat, etc.
2. Use special care while cleaning S.C.B.A. facepieces to remove all moisture to prevent water draining into the exhalation valve and breathing tube. "NEVER SUBMERGE EXHALATION VALVE OR BREATHING TUBE IN WATER".
3. SCBA audio alarms can fail in low temperatures; therefore a visual check of remaining service time should be made.
4. Exhalation valves can freeze in the open position or in the closed position. Know the signs of this problem. (Facepiece test procedure).

11. BREATHING APPARATUS POLICY

This policy of the Hamilton Fire Department covers assignment of apparatus, recording test results, operational inspection and test procedures, operation use, and maintenance after use.

31.0 BREATHING APPARATUS POLICY

32.0 ASSIGNMENT OF APPARATUS TO PERSONNEL

- 32.1 At the start of each shift the Officer or Acting Officer, in charge of an apparatus, shall assign a self-contained breathing apparatus to each member of his crew and to himself, for use during the shift. The unit will be inspected by it's assigned personnel.

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- 32.2 All spare units on the apparatus will also be inspected by the crew of that apparatus at the start of the shift. The person who has inspected that unit will take the responsibility for it's required inspection at that time.
- 32.3 Senior Officers may have their S.C.B.A. checked by their drivers at the start of the shift.
- 32.4 Any personnel who require a S.C.B.A. at a scene of an emergency and has not be assigned one will be assigned a unit at the scene.
- 32.5 A person who has moved from one apparatus to another during a shift will be assigned an S.C.B.A. by the officer on the apparatus he has been assigned to.

33.0 RECORDING TEST RESULTS

- 33.1 Self-contained breathing apparatus shall have the visual inspection, 10 second leakage test and the facepiece test done to it at the start of each shift and after use. S.C.B.A. shall have the cylinder test done at the start of each tour of duty:

Sunday	0800 hours
Wednesday	1800 hours
Friday	0800 hours

and, after use.

- 33.2 At the completion of the tests and inspections, the person carrying out the examination shall sign the log book indicating that the apparatus has been inspected in accordance with the prescribed methods and procedures, and found to be satisfactory for use, at the time of inspection.
- 33.3 Also recorded in the book is cylinder pressure, date and mask number.
- 33.4 A record is also to be kept on the mask use Information to include the mask number, date and duration of use, user and location of use.

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34.0 OPERATIONAL INSPECTION AND TEST PROCEDURE

34.1 At the start of each shift, personnel shall complete the following inspections and tests to their assigned self-contained breathing apparatus:

34.1.1 Visual Inspection

34.1.2 Leakage Test

34.1.3 Cylinder Test (Sun.0800, Wed.1800,
Fri.0800 and after
use)

34.1.4 Facepiece Test

35.0 VISUAL INSPECTION

35.1 Visually inspect the complete apparatus for worn or aging rubber parts and damaged components.

35.2 Visually inspect the cylinder for large dents or gouges.

35.3 Visually inspect the cylinder for discolouration or charring, an indication that the cylinder has been exposed to high heat or flame.

35.4 Check the condition and position of all straps and buckles.

35.5 Check and place the Positive Pressure Lever in the "OFF" position.

35.6 Check to insure that the Main Line Valve (yellow knob) is fully open.

35.7 Check to insure that the By-Pass Valve (red knob) is fully closed.

35.8 Check regulator cover to insure that the three (3) cover screws are present, that they are tight and that the cover is properly positioned, not loose or lifted.

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35.9 Check to insure that the regulator hose HAND CONNECTION to the cylinder valve is HAND TIGHT (no wrenches). DO NOT USE WRENCHES ON THE HAND CONNECTION COUPLINGS.

35.10 NOTE: If unit has not met above requirements, remove it from service.

36.0 LEAKAGE TEST

36.1 Place the Positive Pressure Lever in the "OFF" position.

36.2 Close the Cylinder Valve.

36.3 Fully close the By-Pass Valve (red knob).

36.4 Open the Main Line Valve (yellow knob).

36.5 Sanitize the Regulator Outlet and place the Regulator Outlet to the mouth and inhale to remove any trapped air pressure.

36.6 Close regulator Main Line Valve (yellow knob) by depressing the lock-tab and turning the valve knob fully clockwise.

36.7 Place regulator outlet to mouth and gently inhale; there should be no flow (leakage) through the regulator. The negative pressure which is being applied shall be maintained for approximately 10 seconds.

36.8 Gently exhale with mouth to the regulator outlet; there shall be no flow (leakage) through the regulator. The positive pressure which is being applied shall be maintained for approximately 10 seconds.

36.9 NO LEAKAGE: If no flow (leakage) occurs after following steps 36.1 to 36.8, return regulator to the stand-by position by fully opening the Main Line Valve.

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36.10 LEAKAGE PRESENT: If leakage is present, re-check the by-pass and main line valves to be sure they are fully closed and re-test the unit by repeating steps (36.1 to 36.8). If leakage still persists remove the apparatus from service.

36.11 The regulator shall be sanitized before and after the leakage test.

36.12 NOTE: Remove the unit from service if requirements are not met.

37.0 CYLINDER TEST -- Sun. 0800, Wed. 1800, Fri. 0800 and after use:

37.1 Open the cylinder valve slowly until fully opened.

37.2 Check to insure the Audio Pak Alarm has rung momentarily. If the alarm did not activate on the opening of the cylinder, it must ring when closing the cylinder and bleeding off the residual air.

37.3 Check to insure that the regulator gauge indicator needle and the cylinder pressure gauge indicator needle is showing in the FULL RANGE.

37.4 Check to insure that there are no signs of leakage at the cylinder valve, regulator and all other connections.

37.5 If no leakage occurs, shut off the cylinder valve and bleed off trapped air in the regulator. NOTE: If the unit has not met the above requirements, remove it from service.

38.0 FACEPIECE TEST

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- 38.1 Securely place the facepiece to your face with one hand and place the coupling in the palm of your other hand, closing the opening of the coupling.
- 38.2 Breathe in deeply for 3-5 seconds and insure that the facepiece is collapse your face.
- 38.3 Now exhale releasing the air from the facepiece, with one hand still closing the coupling opening, to insure that the exhalation valve is in the proper working order. It is important that the air expelled is expelled through the exhalation valve.
- 38.4 After the regulator operation inspection, or when the unit is passed to another user, the facepiece is to be disinfected with alcohol preps.
- 38.5 NOTE: If the unit has not met the above requirements remove it from service.

39.0 OPERATIONAL USE

- 39.1 Facial hair, temple bars on spectacles, or anything that will interfere with the face to facepiece seal on respiratory protective equipment, shall not be permitted.
- 39.2 All personnel shall wear self-contained breathing apparatus when there is any question as to the quality of the atmosphere or when entering a contaminated area at a fire or other incidents requiring respiratory protection (exception, para. 39.3). The self-contained breathing apparatus may be removed after the senior officer, along with the officer in the contaminated area, have determined that the area has been thoroughly ventilated and the atmosphere is considered safe.

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- 39.3 It will not be mandatory for officers in charge to use self-contained breathing apparatus while directing operations and maintaining radio communications outside the emergency perimeter. However, they shall don self-contained breathing apparatus when there is any question as to the quality of the atmosphere, or if it is necessary to enter a contaminated area or when known toxic substances are present.
- 39.4 Personnel wearing self-contained breathing apparatus should work together in pairs.
- 39.5 WHEN WEARING SELF-CONTAINED BREATHING APPARATUS THE MAIN BOTTLE VALVE SHOULD BE FULLY OPENED.
- 39.6 When no longer required, S.C.B.A. shall be immediately returned to the apparatus from which it was obtained.
- 39.7 For the safety of all personnel, S.C.B.A. shall be worn, and personnel shall be secured in the jump seat by the S.C.B.A. harness or seat belt when responding to and from all alarms.
- 39.8 This applies to all vehicles equipped with mounted S.C.B.A. in the extended cab portion of the vehicle. Upon arrival and assessment of the emergency, it will be the responsibility of the officer in charge of the apparatus to ascertain if S.C.B.A. is to be utilized or removed. NOTE: It is understood that extenuating circumstances may prevail at specific incidents which may result in departure from this policy.

40.0 AFTER USE MAINTENANCE

- 40.1 In addition to the S.C.B.A. inspection and test described in para. 32.0 to 38.0, include the following rules that shall apply to respiratory protection, for equipment that has been used at an emergency incident.

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- 40.1.1 Appropriate decontamination procedures shall apply when necessary.
- 40.1.2 Respiratory protective equipment shall be checked for signs of damage, wear or heat exposure.
- 40.1.3 Wash the facepiece in luke warm water with soap or a mild detergent (refer to para 44.1).
- 40.1.4 Rinse again with clear water.
- 40.1.5 Wipe the facepiece with a drying towel and allow it to thoroughly dry. Apply a very small amount of anti-fog solution and polish it to a high shine with drying towel.
- 40.1.6 Damp sponge dirt accumulation from rest of the apparatus.
- 40.1.7 Follow "Regulator Operations Inspection" procedure.

The cylinder is fully charged (gauge indicator needle is in the "FULL" range marking).

The cylinder valve is fully closed.

The by-pass valve is fully closed.

The main line valve is fully opened.

The Positive Pressure Lever is in the "OFF" position.

NOTE: Cylinders that have not been used in any three month period should be slowly depressurized and recharged.

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41.0 PLACING S.C.B.A. INTO OPERATION

- 41.1 Don the mask in the proper manner.
- 41.2 Don the facepiece in the proper manner.
- 41.3 Connect the facepiece breathing tube to the regulator outlet.
- 41.4 Turn the Positive Pressure Lever from the "OFF" position to the "ON" position.

42.0 REMOVING S.C.B.A.

- 42.1 The area must be cleared of all contaminants first.
- 42.2 Turn the Positive Pressure Lever from the "ON" position to the "OFF" position, (thus conserving air).
- 42.3 Remove the facepiece.
- 42.4 NOTE: Anytime a positive pressure breathing apparatus is being worn and in use, the positive pressure lever should be in the positive mode (the "ON" position). The following procedures will be used for the cleaning and disinfecting of breathing apparatus regulators and facepieces.

43.0 DRYING TOWELS

- 43.1 Every station has been issued special drying towels that are used after washing the facepieces.
- 43.2 Only a small piece of this towel is needed to dry the facepieces (approximately 20 - 24 cm, or 8 inches).

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44.0 FACEPIECE

- 44.1 After every use the facepiece is to be washed in a solution of luke warm water and a mixture of soap or mild detergent. The mixture should be:

60 ml (4 tablespoons) of LOC per

9 litres (2 gallons) of luke warm water

THE SOAP THE HAMILTON FIRE DEPARTMENT USES IS LOC

- 44.2 It is very important that the exhalation valve and the speaking diaphragm do not get wet.

- 44.3 Grasp the facepiece by the exhalation valve and the breathing tube, using care not to get this part wet and immerse the rest of the facepiece into a bucket of LOC and water. Remove from the clear water and shake off any excess water and dry it with the special drying towels that have been provided.

45.0 DISINFECTING THE REGULATOR

- 45.1 Before and after conducting the Leakage Test to the regulator, the regulator outlet is to be sanitized. All stations have been issued with alcohol preps to perform this function.

- 45.2 NOTE: S.C.B.A. carried on spare apparatus stored in stations will have the regular operational inspection performed at the start of each tour of duty; Sun. 0800, Wed. 1800, and Fri. 0800, and when put into service.

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12. SAFETY

- o Be in good health and physical condition.
- o Check the facepiece seal to be sure there are no leaks.
- o Make sure the equipment is operating properly before entering a hazardous atmosphere.
- o Keep the cylinder harness tight. A loosely fitting unit will slide around and ruin balance or cause injury.
- o Always work in pairs, and stay in oral or visual contact with the other member of the team. Fire departments should appoint safety officers to keep track of self-contained breathing apparatus wearers at emergencies.
- o Stay in contact with a wall, hoseline, or lifeline.
- o Work efficiently to conserve air.
- o Be extremely cautious if forced to breathe through the bypass valve (leave building).
- o Do not under any circumstances take off the facepiece if out of breathing air.
- o Do not take off the facepiece as soon as the fire is knocked down. There are still toxic gases in the air, and there might not be enough oxygen. Self-contained breathing apparatus should always be worn during overhaul inside buildings until they are well ventilated with fresh air and toxic gases are removed.
- o Always report malfunctions and apparent damage immediately.

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13. LIFEGUARD II - PERSONAL DISTRESS DEVICE

The purpose of LIFEGUARD II - to provide an automatic call for help if the wearer should require assistance.

Wearing the Unit - the personal distress device is secured to the S.C.B.A. right shoulder harness where it can easily be seen and reached by the wearer.

TESTING LIFEGUARD II

ALWAYS test unit prior to using in service:

1. Switch unit to the "ARM" position. The tone will sound briefly. Leave unit motionless (by holding steady or setting on table). After 25 to 35 seconds a reduced continuous tone will sound. After 5 to 10 seconds the pulsating distress tone will lock on. Switch unit to "OFF" position.
2. Switch unit to the "ON" position. Distress tone will immediately sound.

HOW TO USE LIFEGUARD II

To arm for automatic distress signalling, switch to the "ARM" position. Tone will sound briefly to indicate arming. If the unit remains motionless for approximately 25 to 35 seconds in the "ARM" position, a reduced continuous tone will sound, indicating another 5 to 10 seconds remain before the unit begins the pulsating distress sound. If a distress situation does not exist, merely moving or tapping the unit will reset the timer and prevent the distress sound, or the unit may be turned to the "OFF" position.

When LIFEGUARD II is in the "ARM" mode, an orange portion of the control knob is visible from the front. This permits easy identification of the wearer or any other person in close proximity that the unit is armed prior to entering a potentially hazardous area.

To use the unit manually in a distress situation (from "OFF" or "ARM" position), switch to "ON" position. Pulsating distress tone will sound until unit is turned to the "OFF" position.

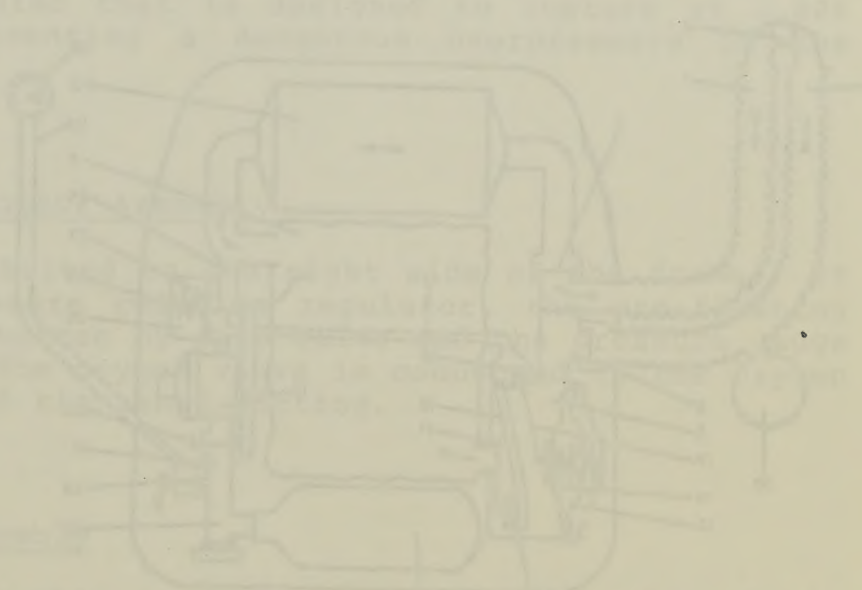
When not in use, be sure switch is in the "OFF" position.

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MAINTENANCE

No adjustment or complicated maintenance is required. If testing (as described above) indicates battery replacement is necessary, just remove the battery cover from back of unit. Use a 9V NEDA 1604A Alkaline Battery (or equivalent), positioned correctly, and attach cover securely.

CAUTION: USE ONLY ALKALINE BATTERIES FOR MAXIMUM ALARM POWER AND RELIABILITY.

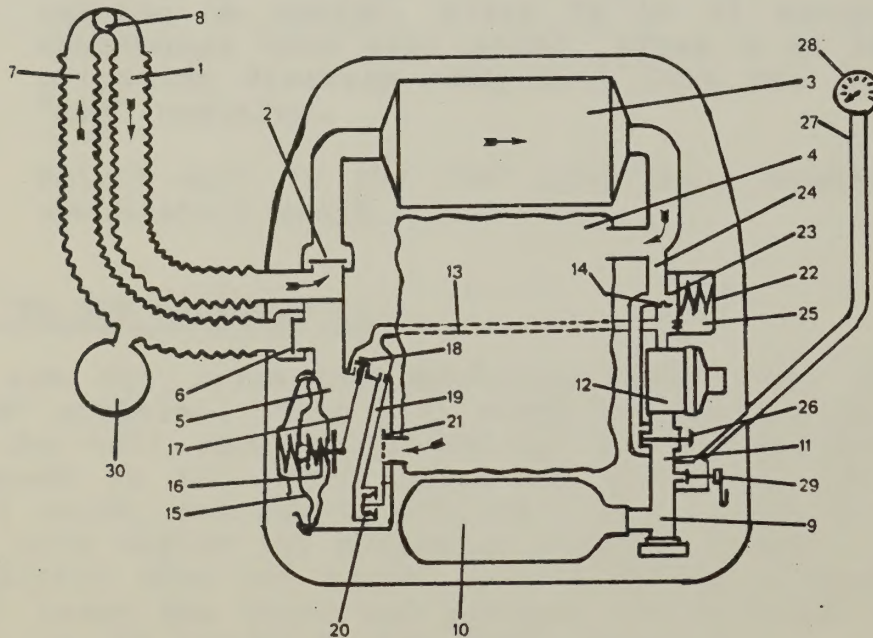


14.

DRAGER MASK - MODEL BG 174

The Drager mask is a lightweight oxygen breathing apparatus of the self contained, closed circuit, regenerative type. A closed circuit mask is one in which the wearer's exhaled air is not allowed to escape to the atmosphere. A regenerative type mask is one in which the exhaled carbon dioxide gas is removed and replaced with oxygen.

In the Drager mask, the wearer's exhaled air is passed through a regenerative canister and then flows into a breathing bag. The breathing air bag has a capacity of 6 litres and serves as a reservoir. The oxygen that is consumed in respiration is replaced by a constant metered flow of 1.5 litres per minute.



- | | | | |
|----|------------------------|----|--------------------------------|
| 1 | Exhalation hose | 16 | Cotter pin with sealing plate |
| 2 | Exhalation valve | 17 | Lung demand valve lever |
| 3 | Regenerating cartridge | 18 | Lung-governed valve |
| 4 | Breathing bag | 19 | Control line |
| 5 | Valve box | 20 | Warning signal control bellows |
| 6 | Inhalation valve | 21 | Warning signal flap |
| 7 | Inhalation hose | 22 | Preflushing device |
| 8 | Apparatus connector | 23 | Preflushing valve |
| 9 | Cylinder valve | 24 | Preflushing line |
| 10 | Oxygen cylinder | 25 | Control chamber |
| 11 | Oxygen distributor | 26 | Manual booster valve |
| 12 | Pressure reducer | 27 | Pressure gauge line |
| 13 | Oxygen line | 28 | Pressure gauge |
| 14 | Dosage nozzle | 29 | Pressure gauge shut-off valve |
| 15 | Control diaphragm | 30 | Saliva trap |

Component Parts

The Drager mask consists of the following parts:

a) Oxygen Cylinder

The oxygen cylinder is a high grade steel alloy cylinder. Atmospheric volume of the cylinder is 2 litres. When charged to a pressure of 14,000 KPa, it contains approximately 270 litres, and at its maximum pressure of 21,000 KPa, it contains approximately 400 litres. The cylinder must be hydrostatically tested every 5 years in compliance with the regulations of the Board of Transport Commissioners of Canada. Test pressure is 30,800 KPa.

The cylinder valve is fitted with a safety cap containing a frangible metal disc that is designed to rupture at 2,800 KPa there-by preventing a dangerous overpressure in the cylinder.

b) Oxygen Distributor Assembly

This assembly is bolted to the right side of the frame. It contains the pressure reducing regulator, the pre-flushing device, the push button by-pass valve and the pressure gauge shut off valve. The oxygen valve is connected to the oxygen cylinder by a hand tightened fitting.

c) Valve Box Assembly

The valve box assembly is located on the left side of the frame. Contained in this assembly are the lung demand lever and valve, the control diaphragm and the pressure relief valve. Also incorporated in the assembly is the audible warning signal, with the tuning reeds.

When the demands of the wearer exceed the metered flow, the control diaphragm moves inward under atmospheric pressure and opens the demand valve. As the pressure in the circuit returns to normal, the demand valve closes.

Should the wearer not consume the full volume of the metered flow, the diaphragm moves outward opening a one way valve to allow the excess oxygen to escape.

The audible warning device, consists of a flap valve in the breathing inlet. The valve is held open when the mask is pressurized, but closes over the breathing inlet when the pressure is removed. Fitted into the flap valve are two acoustical reeds that produce a warning sound similar to a mouth organ when the wearer inhales.

The purpose of the warning device is to alert the wearer in the event that he neglects to open the oxygen valve or to warn him if an empty cylinder has been fitted to the apparatus.

NOTE: THE WARNING DEVICE IS NOT INTENDED AS A SIGNAL TO RETREAT AND MUST NOT BE RELIED UPON AS SUCH. IT DOES NOT FUNCTION UNTIL THE OXYGEN SUPPLY IN THE CYLINDER IS TOTALLY EXHAUSTED.

d) Breathing Tubes and Face Mask

The breathing tubes are made of fabric reinforced rubber. Corrugations allow for extension and prevent the tubes collapsing. A saliva trap in the inhalation tube prevents saliva or condensed moisture entering the demand valve. A metal ring is fastened to the breathing tubes that allows them to be suspended from the carrying harness and relieves the weight on the face mask.

The face mask has a full view lens, fitted with a manual lens wiper. An inner seal on the mask provides a comfortable fit without leakage. The five strap harness must be pulled down at the back before tightening the chin and temple straps.

e) Pressure Gauge and Gauge Line

The pressure gauge is carried in a metal cover on the right side of the wearer's chest. To read the gauge, you simply pull it down, out of the cover and position it in front of the face mask. The gauge reads from zero to 28,000 KPa.

The gauge line is a high pressure hose with a stranded bronze core.

Should the gauge or gauge line be broken, the resulting oxygen leak is small, due to a restricted orifice in the oxygen valve. The leak can be stopped by operation of the gauge line shut off valve. This valve is normally tied in the open position with a fine thread to prevent its being accidentally closed. Closing the gauge line shut off valve does not affect the normal operation of the mask.

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f) Breathing Bag

The rubberized fabric breathing bag has a capacity of 6 litres and is protected by the carrying frame and protective shell.

g) Protective Shell

The protective shell is made of a hardened light metal alloy and covers the whole of the main unit. The top of the shell is held by the carrying strap bar and the bottom by two snap latches.

h) Regenerative Canisters

There are two different regenerative canisters supplied with the unit. One is a disposable canister that is used once and discarded. The other is a refillable canister that is used and is then refilled with fresh chemical. Disposable canisters contain a drying agent in addition to a carbon dioxide absorbing agent. They, therefore, provide drier breathing air and less fogging of the face mask. Disposable canisters are stamped with an expiry date to indicate the usable shelf life. Refillable canisters contain granular soda lime to absorb the carbon dioxide and some of the moisture. After use, the canister is emptied and is then refilled with fresh soda lime. Refilling of canisters must be done properly in order to ensure efficient absorption of carbon dioxide. When refilling, the canister should be held in an inclined position so that the fill opening is uppermost. Periodic shaking and tapping of the canister is recommended during the filling procedure. This packs the granules together and prevents the formation of voids that might otherwise form and interfere with the absorption of gas. The soda lime should be filled to the top of the opening so that the specially designed plug wedges the granules tightly together.

Drager Sorb lime granules contain an indicating agent that turns the granules a bright deep blue when they have reached their carbon dioxide absorption capacity.

The regenerative canister is carried on a rack on the top of the carrying frame. It is so positioned that the heat generated during the gas absorption is dissipated without causing discomfort to the wearer.

Disposable canisters must be inserted so that the arrow stamped on the canister is aligned with the arrow stamped on the rack. Refillable canisters are inserted with the fill cap at the top on the left side carrying frame.

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i) Carrying Frame and Harness

The carrying frame is of light strong alloy with side walls. A padded pack is fitted to the back to provide a comfortable fit.

The padded harness is easy to fasten and comfortable to wear. The shoulder straps are tightened by pulling down on the end ring. the straps may be loosened or released by lifting up on the buckle.

Donning and Wearing

Open the oxygen cylinder valve to the stop and then turn in one half turn. When the valve is turned on, the oxygen pre-flushing can be heard. This consists of a rapid flow of 6 litres to fill the breathing bag and flush out the breathing circuit. After the initial pre-flushing, which lasts several seconds, the metered 1.5 liter per minute constant flow can be heard.

Put the apparatus on and adjust the shoulder straps by pulling down on the rings. Fasten the waist belt and hook the suspension strap to the breathing tubes.

Pour a very small quantity (4.74 ml, (1 tsp.)) of anti-fog solution on to the lens wiper and operate the wiper several times.

Fasten the waist belt and hook the suspension strap to the breathing tubes and put on the mask. Pull the web well down the back of the head to tighten the top strap. Tighten the chin and temple strap to provide a comfortable tight fit. Pinch off the two breathing tubes and inhale, the mask should be drawn in towards the face.

When in operation, the mask functions automatically and should require only an occasional check of the pressure gauge. Checking the pressure gauge and relating the pressure reading to remaining breathing time is very important. The only warning device on the Drager Mask functions when the breathing circuit is not pressurized. It does not serve as a low pressure signal but only as a reminder to open the cylinder valve.

The wearer must check his pressure gauge occasionally to determine his remaining oxygen supply. Tests show that, provided neither the demand valve nor the by-pass valve is used, the breathing time remaining is approximately 20 minutes for each gauge mark.

The breathing bag has a capacity of 6 litres. A man, taking a very deep breath, can inhale approximately 5 litres so that it is very unlikely that the demand valve will operate. The men wearing these masks should leave the hazardous area in time to assure that they will reach fresh air before they run out of oxygen. In no case should they remain in a hazardous atmosphere with less than 2,800 KPa in the cylinder.

Regenerative canisters generate heat as they absorb the carbon dioxide gas. If a canister does not get warm, it is not absorbing the carbon dioxide properly. This condition would be noticed by a build-up of carbon dioxide in the breathing circuit. Carbon dioxide build-up causes an increase of the respiration rate accompanied by a feeling of not getting enough air. If these symptoms occur, operation of the by-pass valve for several seconds will flush out the breathing circuit. Flushing the circuit should provide about ten minutes of breathing time before the carbon dioxide builds to a noticeable level. If the condition does recur, the wearer should vacate the hazardous area and fit a fresh canister to the apparatus.

All of the valves in the oxygen valve are within easy reach of the right hand. The cylinder valve is at waist level in the lower corner of the protective shell. The push button by-pass is just above the cylinder valve. By sliding your fingers up the inside edge of the shell, it is easy to locate the gauge line shut off valve. This valve shuts off the gauge and the gauge line in the event of a leak. It does not interfere with the normal operation of the mask itself. The gauge line valve is simply a small lever that is pushed up (down on some models) to operate. It is normally fastened in the open position by a thread to prevent inadvertent closing. If the valve has been shut off, the problem necessitating this action must be corrected and the valve must be again sealed open.

After Use Care

After removing the apparatus, disconnect the breathing tubes to prevent any contents of the saliva trap draining into the demand valve.

On return to quarters, the unit must be stripped down and cleaned as follows.

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Remove the protective shell by pressing the two snap catches outward and lifting the bottom of the shell outward and upward. Release the canister fittings and remove the regenerative canister. Dispose of used Alkali canister carefully so that alkaline fluid does not get onto the hands or clothes. Refillable soda lime canisters must be emptied as soon as possible after use. If the inside of the tin canister is wet it should be rinsed in clear warm water and dried thoroughly before being refilled. Be certain that canisters are filled properly as they have a very important function. Remove the oxygen cylinder and replace it with a fully charged one.

Disconnect the oxygen pre-flushing line from the breathing bag fitting. Carefully draw back the left end of the breathing bag to expose the threaded connection. After releasing the fitting, remove the breathing bag. Thoroughly rinse the bag in warm water, flushing it out well. Disinfect as instructed and rinse in warm water before drying. Hang bag in warm well ventilated room to dry. Do not expose drying rubber parts to direct sun or temperatures above 90°C. Do not use compressed air for drying. Thoroughly flush out the breathing tubes and saliva trap. Alternately stretch and release the breathing tubes to insure proper washing of the corrugations. Disconnect the oxygen line at valve parts and slide the entire valve unit towards the rear to remove it. Remove the retaining ring from the demand valve and lift out the disc shaped diaphragm housing. Seal off the demand valve with the screw cap and split rubber plug that are provided for the purpose. Thoroughly rinse out, disinfect and rerinse the demand valve chamber, add a small amount of vinegar (5% to the rinse water). After the vinegar rinse, parts should be rinsed in clear water to remove the vinegar odour. Shake all excess water from mask parts to assist in speeding up the drying process. When all parts have been cleaned and dried, re-assemble the unit in the reverse order of dis-assembly. Check all gaskets, sealing washers, and "O" rings to ensure they are not cracked or torn. Use the plastic picks provided as an aid to removal of any damaged gaskets or washers. A full set of replacement washers is included in the service kit.

Periodic Testing And Maintenance

The apparatus must be inspected and tested every three months as follows:

Disassemble the unit and rinse all rubber parts in luke warm water. Work the rubber breathing tubes and the breathing bag to keep the rubber supple. After re-assembly, seal the mask fitting with the sealing cap. Open the oxygen valve and brush soap suds (not detergent) on all fittings to observe any leaks. If a leak cannot be stopped by tightening the fitting hand tight, replace the gasket or gaskets concerned. The soap test may be carried out with an empty canister fitted to the unit.

The diaphragm and the demand valve should be checked out as follows:

Remove the diaphragm disc and visually inspect the rubber diaphragm for signs of aging. Re-install the diaphragm disc and turn on the oxygen cylinder, gently press the breathing bag and listen for oxygen escaping from the pressure relief valve through the diaphragm vent. Gently blow into the diaphragm vent and the demand valve should open as evidenced by a rush of oxygen into the circuit. Conduct the demand valve test with the breathing tubes open to prevent excessive pressure building up in the circuit.

It is recommended that the periodic tests be carried out as a part of the cleaning process after the masks have been used in a training session.

No lubrication of any kind is required or recommended on any part of this apparatus. Use of oil or grease on apparatus exposed to high pressure oxygen may result in a fire or explosion.

For supplies of soda lime or other equipment regarding the apparatus, contact Station #1.

For routine testing of cylinder pressure, remove the cylinder from the unit, attach the test gauge and open the cylinder valve. This procedure eliminated the waste of oxygen that would otherwise occur.

Recommendations

Drager masks should only be worn by qualified personnel that have been trained in their use.

Personnel wearing Drager masks should be paired off with each other and not with a man wearing any other type of mask.

Oxygen cylinders and regenerative canisters must be recharged after each use in order to use the full potential of the mask.

Drager masks may be used to advantage at multiple alarm fires or for rescue etc. Where prolonged operation is desirable.

When Drager masks are being used, the alarm room is to be notified so that arrangements may be made for cylinder recharge.

FOR ADDITIONAL INFORMATION REFER TO I.F.S.T.A. MANUAL.

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CHAPTER 4

FIRST AID FIRE EXTINGUISHERS

1. GENERAL INFORMATION

Fire extinguishers are first aid appliances, designed to extinguish small fires before they reach major proportions. Use of the proper type and in the proper location for the hazard involved increases the likelihood of extinguishing fires with a minimum property loss. Familiarity with the operation of extinguishers is essential to all personnel who may have to use them. Hand fire extinguishers have the same function as larger capacity equipment to confine and extinguish the fire.

Principles of Extinguishment

- a) Cooling the burning material below the ignition temperature.
- b) Smothering the fire by excluding the supply of oxygen from burning materials. OR
- c) By a combination of the above.

Classification of Fires

CLASS "A" - Fires involving ordinary combustible materials such as wood, paper, textiles, etc.

CLASS "B" - Fires in flammable liquids such as paint, alcohols, oils, gasoline, greases, ethers, acids, etc.

CLASS "C" - Fires involving charged electrical equipment, such as switchboards, motors, wiring, etc.

CLASS "D" - Fires involving combustible metals such as magnesium, sodium, potassium, lithium, etc. These fires produce extreme heat.

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Extinguishants

Each class of fire requires a certain type of extinguishant.

CLASS "A" fires require an extinguishant that will cool, preferably water or solutions containing large quantities of water.

CLASS "B" fires require an extinguishant that will blanket or smother it. It may be an extinguishant that is lighter than the liquid involved in fire and will float on the surface of the liquid, or it may be a volatile non-flammable liquid that vaporizes quickly in the presence of heat and displaces the oxygen of the air with incombustible vapors and gases, or it may be an incombustible gas which when released displaces the oxygen of the air, or even a dry chemical which in the presence of heat gives off an incombustible gas to displace the oxygen in the atmosphere. These actions prevent oxygen from getting to the fire and in the case of the floating blanket, vaporization of the liquid is retarded.

CLASS "C" fires require an extinguishant that is a non-conductor of electricity and one that will do the least damage to the electrical equipment involved in fire.

Fires involving CLASS "D" materials develop extreme heat while producing very little flame. Their affinity for oxygen is so great that they will react violently in an atmosphere of carbon dioxide. Any water applied to this type of fire, will decompose into its constituent elements, oxygen and hydrogen. Oxygen readily supports the combustion, while the hydrogen released adds to the intensity of the fire. For these reasons the common extinguishing materials such as water, water solutions, or inert gases are not effective and in fact may react violently when applied to a CLASS "D" fire. To extinguish this class of fire it is necessary to apply special extinguishing agents (described further on in this chapter) in a manner that will form a crust over the burning material, which excludes oxygen.

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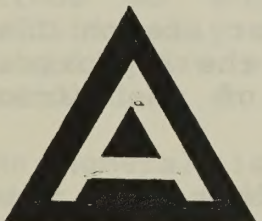
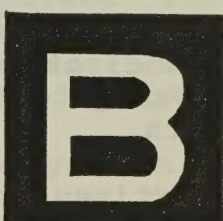
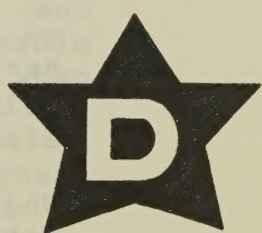
Extinguishants, to be of any practical value, must be provided with a suitable means of expelling them from their storage compartments and propelling them to the seat of the fire.

When in use, all extinguishers should be kept in the upright position. When an extinguisher is in a horizontal position, the gas which propels the extinguishant is allowed to escape, thus cutting down the efficiency of the extinguisher.

The methods of expelling are as follows:-

1. Hand generated pressure (mechanical hand pumps)
2. Stored pressure (internal air or gas pressure)
3. Cartridges of compressed carbon dioxide gas (to be punctured)

Extinguisher Markings

ORDINARY	FLAMMABLE	ELECTRICAL	COMBUSTIBLE
			
COMBUSTIBLES	LIQUIDS	EQUIPMENT	METALS
(GREEN TRIANGLE)	(RED SQUARE)	(BLUE CIRCLE)	(YELLOW STAR)

Note: If an extinguisher is suitable for more than one class of fire, it will be so indicated.
(e.g. Multi-purpose, Dry Chemical "A.B.C.")

Hydrostatic Pressure Test for Extinguishers

This is a manufacturers' test. Water under pressure is pumped into the extinguisher and it is checked for signs of failure. The Ontario Fire Code Sub Section

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6.2.7 makes provisions for inspection, testing and maintenance of extinguishers. This test is conducted on extinguishers every 5 to 12 years depending on the type of extinguisher.

Fire Extinguisher Ratings

Ratings have been based on the above fire classifications, and on carefully controlled standard test fires for the different fire classifications. These tests are conducted in Canada by the Underwriters' Laboratories of Canada. Extinguishers that meet the exacting standards of the Underwriters' will receive an appropriate rating.

These ratings consist of a Numeral and a Letter, or multiple combinations of these. These numerals and letters appear on the Underwriters' label attached to the individual extinguishers.

These NUMERALS AND LETTERS indicate the following:-

In the case of extinguishers suitable for use on CLASS "A" fires, the NUMERAL is indicative of the approximate relative fire extinguishing potential of the various size CLASS "A" extinguishers.

Units which successfully extinguish a fire in a 5 sq. metre vertical wood panel will receive a 1-A rating.

An extinguisher rated 2-A can be expected to put out roughly twice as much fire, and an extinguisher rated 4-A can be expected to extinguish four times as much fire as an extinguisher rated 1-A.

A factor of 2 1/2 is applied to distinguish between test conditions and use in the field.

This factor is applied to the surface area of the test fire, and resultant is amount of fire the average operator can expect to extinguish with a particular type of "A" extinguisher.

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In the case of extinguishers suitable for use on CLASS "B" fires; the number which precedes the "B" indicated the approximate relative extinguishing potential of the various types and sizes of CLASS "B" extinguishers, and in addition, is an approximate indication of the square metre surface area of deep layer flammable liquid fire that an average operator could extinguish.

Underwriters' employ a factor of 2 1/2 to distinguish between test conditions and emergency use of these units by untrained individuals.

In the case of CLASS "B" extinguishers, this factor is applied to the surface of the fire.

An extinguisher has to extinguish a gasoline fire with a surface area of approximately 1/4 sq. metre in order to obtain a 1-B rating.

Extinguishers designed to handle large fires will be tested on proportionately larger surface areas. Thus, a 2-B extinguisher handles approximately 1/2 sq. metre of fire, and an 80-B handles a test fire with a surface area of 20 sq. metres.

For example, a 4-B unit can be expected to handle four times as much surface fire as a 1-B unit, and additionally can be expected to extinguish a flammable liquid fire with a surface area of 1 sq. metre when handled by an average operator.

No numeral is employed in the case of extinguishers that are rated for use on CLASS "C" fires since no tests of extinguishing potential are made.

The "C" designation simply means that Underwriters' are satisfied that the agent is a non-conductor, and as such is completely safe for use on CLASS "C" fires.

Since most CLASS "C" units also have a CLASS "B" rating, a general idea of the extinguisher potential can be obtained by noting which number precedes the "B".

CLASS "D" Extinguishers - Do not contain a numerical rating. The effectiveness of the extinguisher on CLASS "D" metals is detailed on the face plate.

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Multiple letters or numerical letter ratings are used on extinguishers which are effective on more than one class of fire.

To summarize, the LETTER OR LETTERS which appear on the approval label indicate the class/es of fire on which the particular extinguisher is suitable and effective.

The NUMERAL OR NUMERALS indicate the approximate extinguishing potential, depending on the fire classification it relates to.

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2. TYPES OF EXTINGUISHERS

a) Dry Chemical

- i) Ammonium phosphate base (A.B.C.).
- ii) Potassium bicarbonate base (Purple K) - In service H.F.D.
- iii) Sodium bicarbonate base (Ordinary) - In service H.F.D.
- iv) Potassium bicarbonate urea base (Monex).

b) Carbon Dioxide - In service H.F.D.

c) Halogenated Extinguishing Agents

- i) Bromotrifluoromethane (Halon 1301).
- ii) Bromochlorodifluoromethane (Halon 1211).

d) Water

e) Water (Antifreeze calcium chloride)

f) Water (Wetting Agent)

g) Dry Powder

- i) G-1 Powder.
- ii) Met-L-X Powder - In service H.F.D.

h) Foam - A.F.F.F. (Aqueous film forming foam) - In service H.F.D.

Note: Don't confuse DRY CHEMICAL with DRY POWDER extinguishers. DRY CHEMICAL smothers by blanketing whereas DRY POWDER smothers by forming a crust.

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Obsolete Extinguishers

In 1969, the manufacture of all inverting type extinguishers was discontinued. This includes soda-acid, foam and cartridge operated water and loaded stream extinguishers. It is estimated that there are still several million inverting-type extinguishers in use.

3. DESCRIPTION OF EXTINGUISHERS

a) Dry Chemical Extinguisher - Ordinary Base

Size: 9 Kg

Applicable To: Class B and C Fires, Surface A.

Discharge Reach Under Normal Conditions: Approximately 3 metres.

Discharge Time Under Normal Conditions: Approximately 30 seconds.

Protect From Freezing: No.

Method of Extinguishment: Smothering by blanketing.

Operating Principle: The chemical compound in dry chemical extinguishers consists principally of sodium bicarbonate, ammonium phosphate, or potassium chloride which has been chemically processed to make it moisture resistant and free flowing. This compound is discharged under pressure and directed at the fire.

Construction: The extinguisher may contain a cartridge of carbon dioxide or nitrogen gas, either inside or alongside the main container, to expel the dry chemical. When the pressure is allowed to enter the main cylinder, the dry chemical may be expelled upon opening the shut-off nozzles. Some extinguishers are pressurized with inert gas or DRY air and do not have cartridges.

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Method of Operation: In the case of cartridge operated extinguishers, release of the gas in the cartridge pressurizes the dry chemical chamber and expels the dry chemical. The discharge is controlled by a shut-off valve. With a pressurized dry chemical extinguisher, both the dry chemical and expellant are stored in a single chamber and the dry chemical may be expelled by opening the extinguisher valve. Release of the extinguisher valve provides a shut-off feature. In either case, operation expels a cloud of dry chemical from the nozzle. Best results are obtained by attacking the near edge of the fire and progressing forward moving the nozzle with a side to side sweeping motion. When used on electrical fires, care should be taken around open low voltage contacts to prevent costly cleaning. It may be better to use other agents in such cases.

Some extinguishers have relatively high velocity nozzles and to prevent splashing when used on depths of flammable liquid, care should be taken to direct the initial discharge from a distance not closer than 2 metres. This warning is usually prominently marked on the extinguisher nameplate. On surface fires involving liquids the discharge should be directed at least 1 metre above the flame from a distance of 3 metres. By this procedure, the dry chemical provides a coating on surface areas ahead of flash fires which tends to retard the progressing of the fires. After this application, the discharge can be directed at the initial fire without the danger of spreading the fire. The discharge should be applied to the burning surface even after the flames are extinguished, to prevent the possible reflash by coating the hot surface and any flowing materials present.

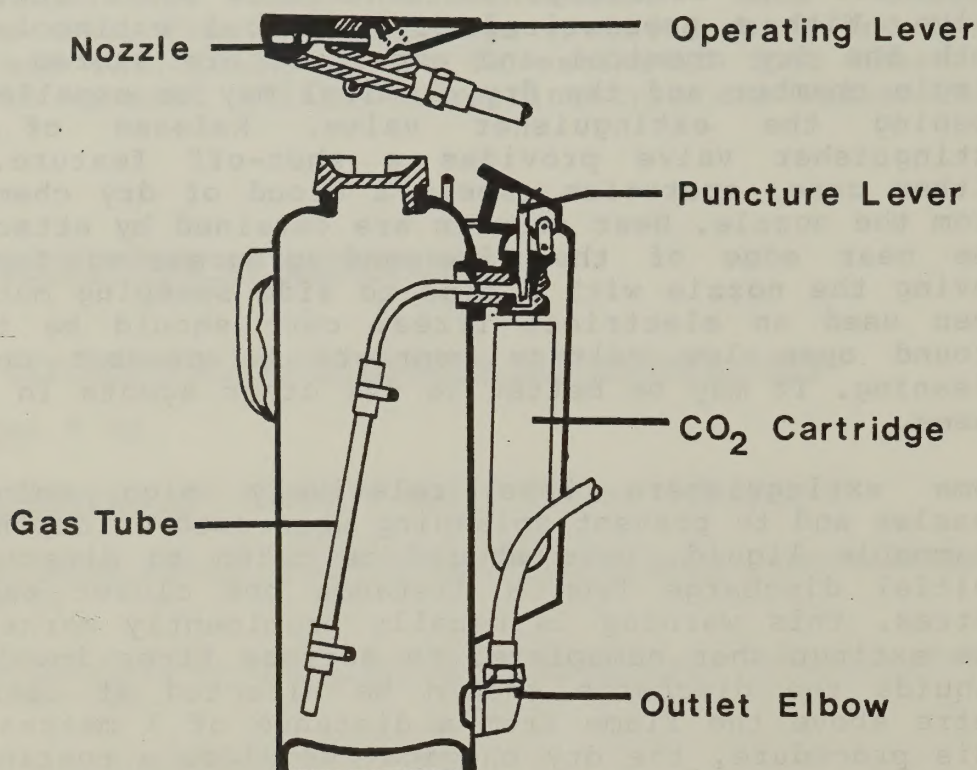
Recharge: After use, or if pressure drops on gauge.

Note: "SAFETY" - Invert and bleed off any excess pressure before removing filler cap.

Method of Inspection: Check powder for substitutions and solidification by opening the filler cap in the base or top of the extinguisher. Examine hose and hose couplings for serviceability. Examine hose and nozzle for obstructions. Examine nozzle for serviceability.

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Examine soldered joint or tubing. Weigh gas cartridge. Check wheel-valve assembly, rubber washer and vent hole in cap for serviceability.



Two Other Dry Chemical Extinguishers With Similar Specifications:-

i) Multi-Purpose Base Dry Chemical Extinguishers (A.B.C.)

Multi-purpose dry chemical (monoammonium phosphate and barium sulphate) is a mixture of chemicals in powder form found suitable for use on incipient fires in ordinary combustible materials (Class A) as well as on Class B and C fires. They are NOT recommended for use in connection with fires in combustible metals (Class D fires), unless stated so on the nameplate. The extinguishers are available in a wide range of sizes and are designed identical to other dry chemical extinguishers. On Class B and C fires, the method of operation is the same as the standard dry chemical units. CARE SHOULD BE TAKEN TO AVOID CONTAMINATION OF ANY TYPE DRY CHEMICAL WITH MULTI-PURPOSE TYPE.

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On fires in ordinary (Class A) combustibles, the discharge should be directed at the burning surfaces to cover them with chemical. When the flames have been extinguished, the chemical discharge should be intermittently directed on any glowing areas. Careful watch should be maintained for hot spots that may develop and additional agent applied to those surfaces as required to adequately coat them with the extinguishing agent.

Multipurpose base dry chemical extinguishers have a mixture of chemicals which can be used on Class A, B, and C fires, but not on Class D – no matter what this label might indicate about 'all fires.'



ii) Potassium Bicarbonate (Purple "K")

Has a most effective extinguishing ability on Class "B" and Class "C" fires.

b) Carbon Dioxide Extinguisher

Size: 7 Kg.

Applicable To: Class B and C Fires, Surface A.

Discharge Reach Under Normal Conditions: Approximately 2 metres.

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Discharge Time Under Normal Conditions: Approximately 35 seconds.

Protect From Freezing: No.

Method of Extinguishment: Cooling and smothering.

Operating Principle: Carbon dioxide extinguishers operate on the principle of an inert gas, carbon dioxide (CO₂), which normally will not support combustion, being discharged thereby smothering the fire. The carbon dioxide is stored under pressure eliminating the need for any chemical reactions as required in some other type extinguishers.

Construction: Carbon dioxide extinguishers consist of a high pressure cylinder, discharge valve, discharge hose or tube, and discharge horn. The discharge horn is made of a non-conducting material to permit its use in connection with Class C fires. The carbon dioxide extinguishing agent (CO₂) is retained in a cylinder under pressure in the liquid condition at normal temperatures. Carbon dioxide at ordinary temperatures and atmospheric pressure is a gas, one and one-half times as heavy as air, but is readily reduced to a liquid by applying suitable pressure. The pressure in the container is the vapor pressure of the carbon dioxide, which varies with the temperature. At ordinary room temperature the pressure will be approximately 5500 KPa.

Since the vapor pressure rises rapidly as the temperature increases, carbon dioxide extinguishers should be protected from high temperatures.

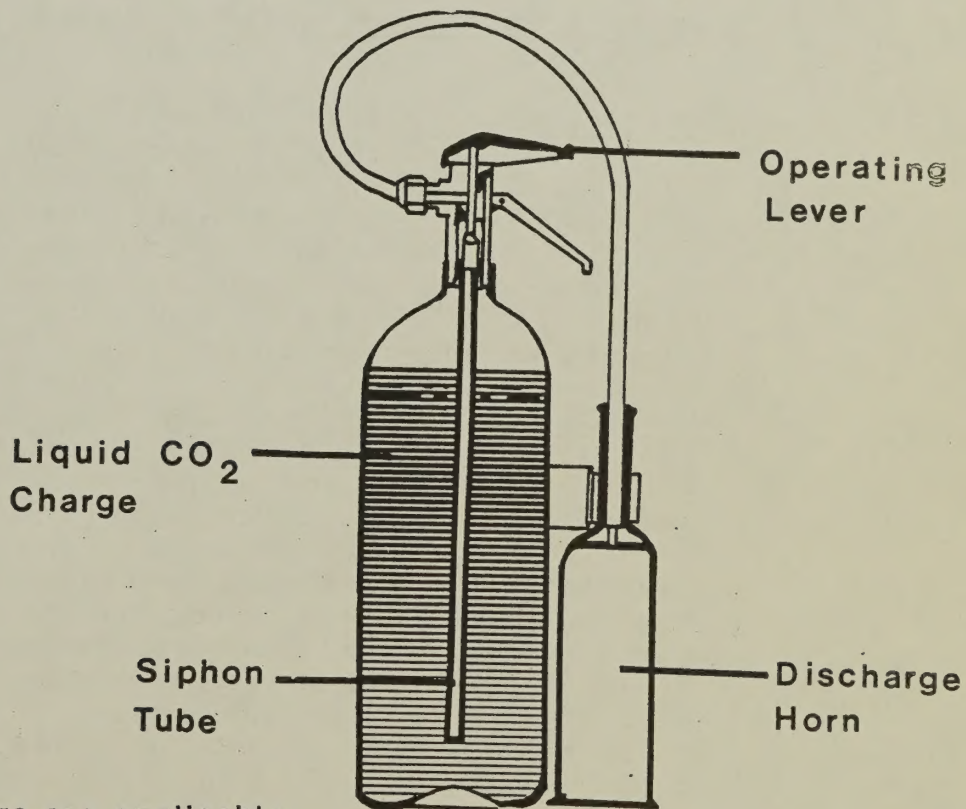
Method of Operation: The discharge expels a cloud of carbon dioxide (CO₂) gas with some "snow" through the nozzle horn. CAUTION: Do not handle the "snow" because frostbite could result. The discharge horn should be pointed at the base of the fire. The discharge should be applied to the burned surface even after the flames are extinguished. This deposit of carbon dioxide snow coats the hot surface and any glowing material present and tends to prevent possible reflash of the fire. On flammable liquid fires, best results are obtained when the discharge from the extinguisher is employed to sweep the flame off the burning surface, applying the

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discharge first at the near edge of the fire and gradually progressing forward, moving the discharge cone very slowly from side to side. In using extinguishers of this type, especially in unventilated places such as small rooms, closets, or confined spaces, operators and others shall take precautions to avoid the effects which may be caused by breathing the vapors or gases liberated or produced. The hazard is the exclusion of oxygen.

Recharge: After use and if loss in weight is more than 10% of the full weight stamped on the extinguisher. Weigh periodically

Method of Inspection: Examine sealing wire for break. Check hose and nozzle for serviceability.



Carbon dioxide extinguishers are applicable to Class B and C fires and have the advantage of leaving no damaging residue on electrical equipment or foodstuffs.

Check to determine if the extinguisher has been tampered with. If the wire or plastic seal and lockpin are still in place, the extinguisher is probably charged for use.

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c) Aqueous Film Forming Foam Extinguisher

Size: 10 Litre.

NOTE: Although AFFF concentrate is intended for use in air aspirating hardware, it may be used with some decrease in certain performance characteristics in non-air aspirating hardware.

Applicable To: Class A and B fires.

Stream Reach Under Normal Conditions: 9 metres

Discharge Time Under Normal Conditions: 60 seconds.

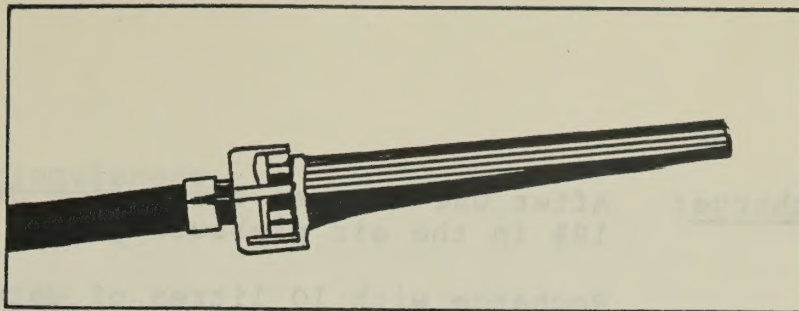
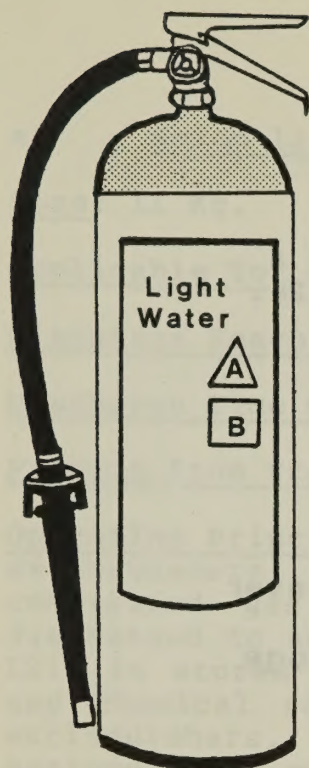
Protect From Freezing: Yes, unless antifreeze solution added.

Operating Principle: The water and aqueous film forming foam (AFFF) solution is ejected by compressed air which is stored in the same shell or chamber with the solution. When the shut-off device is released, the solution is expelled through the hose and aspirator, where air mixes with the solution and forms the foam. With this type, the pressure is ready to propel the extinguishing agent at any time.

Method of Operation: Use in accordance with the instructions on the label. Basically, this includes pulling the pin and squeezing the lever. A special aspirator nozzle creates the foam from the 6% AFFF solution. Do not approach the fire closer than necessary. Use side to side sweeping motions across the entire width of the fire, but avoid splashing liquid fuels. This special foam has the ability to make water float on fuels which are lighter than water. The vapor seal created extinguishes flame and prevents reignition. The foam also has good wetting and penetrating properties on Class A fires.

Recharge: The standard 10 litre extinguisher should only be recharged with a special kit by experienced personnel to insure the proper mixtures in the solution.

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The inverting type of foam fire extinguisher is now obsolete, but a modern extinguisher with a new foam is able to put out a flammable liquid fire in less than half the time of the regular foam. The foam spreads over the surface of burning fuel forming a blanket in the manner of regular foams. More important, an aqueous solution drains from the foam bubbles and forms a vapor-sealing film which has a resealing action to prevent reflash should the foam be disrupted. This foam can also extinguish Class A fires.

d) Stored Pressure Water Extinguisher

Size: 10 Litres.

Applicable To: Class A Fires.

Stream Reach Under Normal Conditions: 11 metres.

Discharge Time Under Normal Conditions: 10 litres; approximately 1 minute.

Protect From Freezing: Yes, unless containing antifreeze solution.

Method of Extinguishment: Cooling.

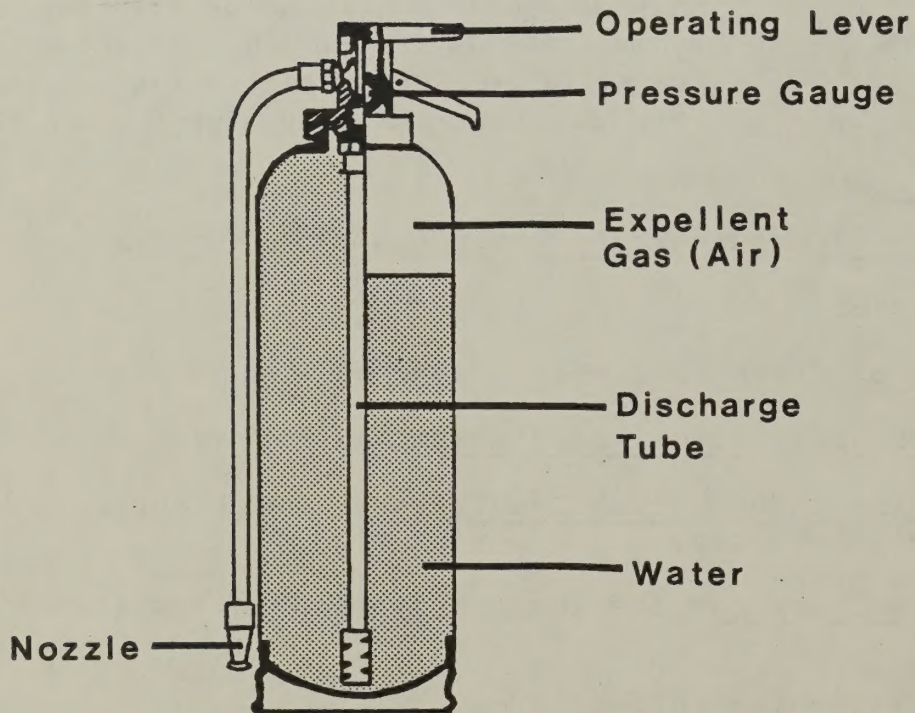
Operating Principle and Construction: The water is ejected by compressed air which is stored in the same shell or chamber with the water. When the shutoff device is released, a stream of water is expelled through the hose. With this type the pressure is ready to release the extinguishing agent at any time.

Method of Operation: Use in accordance with the instructions on the faceplate of the extinguisher. The hose is held in the operator's hand at all times, ready for use. Direct the stream at the base of the fire.

(1986)

Recharge: After use or when there is a drop of 10% in the air pressure gauge.

Recharge with 10 litres of water and a source of air that will supply 700 KPa.



(1986)

e) Halon 1211 Extinguishers

Size: 11 Kg.

Applicable To: Class B and C Fires.

Discharge Reach Under Normal Conditions: 3 metres.

Discharge Time Under Normal Conditions: 25 seconds.

Protect From Freezing: No.

Operating Principle: Halon 1211 (Bromochlorodifluoromethane) extinguishers operate on the principle of liquified compressed gas which will not support combustion being discharged to smother and terminate flame propagation. Halon 1211 is stored under pressure which eliminates the need for any chemical reaction that may be required by some older extinguishers. Construction: Bromochlorodifluoromethane extinguishers consist of a high pressure cylinder, pressure gauge discharge valve, discharge hose or tube, and a discharge horn. The discharge horn is a non-conductor of electricity which permits its use with electrical equipment. The gas is retained within the cylinder under pressure in a liquid condition at normal temperatures. It is readily reduced to a liquid by applying adequate pressure. The pressure in the container is the vapor pressure of the gas agent. At ordinary room temperature the pressure in the container will be approximately 1700 KPa.

Method of Operation: These extinguishers are intended primarily for use on Class C fires but they are effective on Class B fires as well. They have a limited range and the discharge of the extinguishing agent may be affected by draft and wind. The initial application should be made close to the fire and the discharge should be directed at the base of the flames. The discharge should be applied to the burned surface even after the flames are extinguished. Best results will be obtained on flammable liquid fires (Class B) if the discharge is directed to sweep the flame from the burning surface. Apply the discharge first at the near edge of the fire and gradually progress forward while moving the discharge cone slowly from side to side. When these extinguishers are used in confined places, operators should avoid breathing the gases which may be produced by thermal decomposition of the agent.

(1986)

Recharge: In accordance with instructions displayed on face plate.

Note: Halon extinguishing systems are very prominent in fixed extinguishing systems.

f) Extinguishers and Powder Extinguishing Agents for Metal Fires Class D

Fires of high intensity may occur in certain metals. Ignition is generally the result of frictional heating, exposure of the metal to moisture, or exposure to a fire in other combustible materials. The greatest hazard exists when these metals are in the molten state or in finely divided forms of dust, turnings, or shavings. While reasonable precautions in handling and storage will prevent ignition of these metals, there are occasional fires which must be controlled or extinguished.

Normal extinguishing agents generally should not be used on metal fires (Class D). Specialized techniques and extinguishing agents have been developed to control and extinguish fires of this type. A given agent does not, however, necessarily control or extinguish all metal fires. Some agents are valuable in working with several metals; others are useful for combating only one type of metal fires. Approved extinguishing agents are available in dry powder form. Some of the agents are intended to be applied by means of a hand shovel or scoop, others by means of portable fire extinguishers designed for use with dry powders, and some are approved for application by either method. The application of the agent should be of sufficient depth to adequately cover the fire area and provide a smothering blanket. The agent should be applied gently on metal fires to avoid breaking any crust which may have formed over the burning metal. When the crust over the burning metal is broken, the fire usually flares up and exposes more raw material to combustion.

Additional applications may be necessary to cover any hot spots which may develop. The material should be left undisturbed until the mass has cooled before disposal is attempted. Care should be taken to avoid scattering the burning metal.

(1986)

Fires in small or large quantities of finely divided combustible metal or combustible metal alloy scraps which are moist or wet with water or water-soluble machining lubricants on water-wetted surfaces, are likely to burn so rapidly and develop so much heat (may be of explosive nature) that they cannot be approached closely enough to permit proper application of the extinguishing medium. When the burning metal is on a combustible surface, the fire should first be covered with powder, then a one-or-two inch layer of powder spread out nearby and the burning metal shoveled onto this layer with more powder added as needed.

g) Met-L-X Dry Powder Extinguisher - Class D

Size: 14 Kg.

Applicable To: Class D

Discharge Reach Under Normal Conditions: 2 metres.

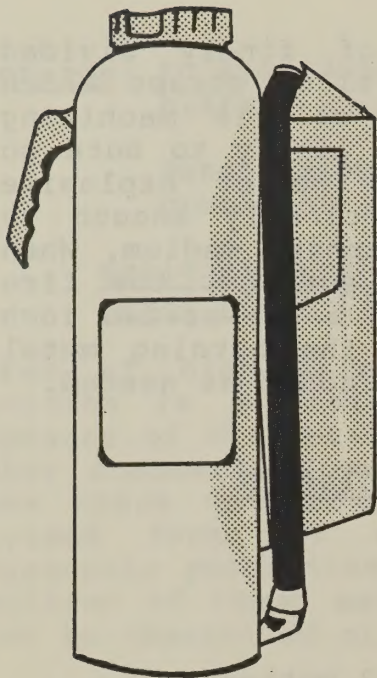
Discharge Time Under Normal Conditions: 30 seconds.

Protect From Freezing: No

Method of Operation: Application of a thin layer of extinguishant from a safe distance prevents blowing the metals onto other areas. Once the fire is controlled a heavier layer may be applied from a closer range. Heat from the fire will cause the powder to cake, forming a crust, which excludes air and results in extinguishment.

Recharge: After use with sodium chloride base with additives to keep it free flowing.

(1986)



Class D fire extinguishers for metal fires resemble ordinary base dry chemical extinguishers, but handling metal fires requires more training and knowledge. As only a general rule, an operator should plan to apply 2 kg of powder per kg of burning metal.

AS THE AGENT FORMS A CRUST OVER THE METAL, WATCH FOR ANY BREAKUP OR CRACKS WHICH WOULD ALLOW THE FIRE TO CONTINUE.

G-I POWDER - CLASS D

G-I Powder is composed of screened graphitized foundry coke. The graphite acts as a heat conductor to absorb heat from the fire and lower the temperature of the metal below its ignition point. The closely packed graphite also smothers fire.

The packing characteristics of the powder prevents its discharge through a fire extinguisher. Instead it is available in cardboard tubes or metal containers equipped with a scoop or shovel for application on fires. In these containers it can be stored for long periods of time without deterioration or caking.

NOTE: FOR ADDITIONAL INFORMATION REFER TO I.F.S.T.A. MANUAL.

(1986)

CHAPTER 5

FIRE BEHAVIOUR

1. INTRODUCTION

Effective fire control and extinguishment requires a basic understanding of the chemical and physical nature of fire. This includes information describing sources of heat energy, composition and characteristics of fuels, and environmental conditions necessary to sustain the combustion process.

Combustion is the self-sustaining process of rapid oxidation of a fuel being reduced by an oxidizing agent along with the evolution of heat and light. Most fires involve a fuel that is chemically combined with the oxygen normally found in atmospheric air. Atmospheric air contains 21 percent oxygen, 78 percent nitrogen, and 1 percent of other gases. Substances such as chlorine gas and its compounds will also sustain combustion. Other substances, such as organic peroxides, are composed in such a way that they contain both fuel and oxidizer molecules within the compound allowing them to burn in the absence of oxygen.

Fires are defined by their physical characteristics. They may vary from very slow oxidation, as in rusting, to very fast oxidation, such as detonations and explosions. Somewhere between these extremes are two most common reactions concerning firefighters: smoldering fires and flaming or free-burning fires.

DEFINITIONS

Following are some terms used to define and describe fire activity:

FIRE - Fire is a chemical reaction known as combustion. It is defined as the rapid reaction between a combustible substance and oxygen, which produces carbon dioxide (and any other gases), water and energy. The energy is in the form of heat and light.

(1986)

FLAMMABLE LIQUIDS - These are fluids having a flash point below 37.8°C .

COMBUSTIBLE LIQUIDS - are those liquids that have flash points at or above 37.8°C .

HEAT - The form of energy that raises temperature. Heat is measured by the amount of work it does.

JOULE - The amount of heat needed to raise the temperature of one gram of water, one degree centigrade.

CENTIGRADE (Celsius) - On the Centigrade scale, zero is the melting point of ice; 100 degrees is the boiling point of water.

BOILING POINT - The temperature of a substance where the rate of evaporation exceeds the rate of condensation.

FLASH POINT - The minimum temperature at which a liquid fuel gives off sufficient vapors to form an ignitable mixture with the air near the surface. At this temperature, the ignited vapors will flash, but will not continue to burn.

FIRE POINT - The temperature at which a liquid fuel will produce vapors sufficient to support combustion once ignited. The fire point is usually a few degrees above the flash point.

IGNITION TEMPERATURE - The minimum temperature to which a fuel in air must be heated in order to start self-sustained combustion independent of the heating source.

ENDOTHERMIC HEAT REACTION - A chemical reaction where a substance absorbs heat energy.

EXOTHERMIC HEAT REACTION - A chemical reaction where a substance gives up heat energy.

FLAMMABLE OR EXPLOSIVE LIMITS - The percentage of a substance in air that will burn once it is ignited. Most substances have an upper (too rich) and a lower (too lean) flammable limit.

(1986)

FLAMMABLE OR EXPLOSIVE LIMITS Cont'd

- It is also referred to as the percentage of a substance in air between the UPPER and LOWER EXPLOSIVE LIMITS.

- | | | |
|---------------------------|----------|---------|
| - i.e. <u>Natural Gas</u> | - U.E.L. | - 13.9% |
| | - L.E.L. | - 4.6% |
| Explosive Range | | - 9.3% |

<u>Ethylene Oxide</u>	- U.E.L.	- 100%
	L.E.L.	- 3.6%
Explosive Range		- 96.4%

LOWER EXPLOSIVE LIMIT - (L.E.L.) - the minimum concentration of vapour, in air, below which propagation of flame does not occur on contact with a source of ignition.

Below Lower Explosive Limit - TOO LEAN TO BURN.

UPPER EXPLOSIVE LIMIT - (U.E.L.) - is the maximum concentration of vapour, in air, above which propagation of flame does not occur on contact with a source of ignition.

Above Upper Explosive Limit - TOO RICH TO BURN.

(1986)

OXIDATION - The complex chemical reaction of organic materials with oxygen or other oxidizing agents in the formation of more stable compounds.

CATALYST - A substance which alters the speed of a chemical reaction, but is itself unchanged by the reaction.

CHEMICAL CHANGE - One in which the composition of the substance is altered, resulting in the formation of one or more new substances with different properties.

CRITICAL TEMPERATURE - This is termed as the highest temperature at which gas or vapour may be converted to the liquid state by the application of pressure.

FLAMMABILITY - Flammability and inflammability are the same thing, which is: The property of a substance which makes it possible for it to burn when exposed to heat.

INERT GAS - A gas that will not readily enter into chemical reaction, and is therefore not combustible. Its danger lies only in the fact that its presence may reduce the oxygen content of the air.

MISCIBILITY - Ability to mix. The miscibility of a flammable liquid with water is important in fire-fighting, since the flash point and fire points of a flammable liquid are appreciably raised as the amount of water in the mixture is increased.

2. SOURCES OF HEAT ENERGY

Heat is a form of energy that may be described as a condition of "matter in motion" caused by the movement of molecules. All matter contains some heat regardless of how low the temperature is because molecules are constantly moving all the time. When a body of matter is heated, the speed of the molecules increases, and thus, the temperature also increases. Anything that sets the molecules of a material in motion produces heat in that material. There are four general categories of heat and energy and they include:

(1986)

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(1986)

- Chemical heat energy
- Electrical heat energy
- Mechanical heat energy
- Nuclear heat energy

Chemical Heat Energy

Heat of Combustion - The amount of heat generated by the combustion (oxidation) process.

Spontaneous Heating - The heating of an organic substance without the addition of external heat. Spontaneous heating occurs most frequently where sufficient air is not present to dissipate the heat produced.

Heat of Decomposition - The release of heat from decomposing compounds. These compounds may be unstable and release their heat very quickly or they may detonate.

Heat of Solution - The heat released by the mixture of matter in a liquid. Some acids, when dissolved, give off sufficient heat to pose exposure problems to nearby combustibles.

Electrical Heat Energy

Resistance Heating - The heat generated by passing an electrical force through a conductor such as a wire or an appliance.

Leakage Current Heating - The heat resulting from imperfect or improperly insulated electrical materials. This is particularly evident where the insulation is required to handle high voltage or loads near maximum capacity.

Heat From Arcing - Heat released either as a high-temperature arc or as molten material from the conductor.

(1986)

Static Electricity Heating - Heat released as an arc between oppositely charged surfaces. Static electricity can be generated by the contact and separation of charged surfaces or by fluids flowing through pipes.

Heat Generated by Lightning - The heat generated by the discharge of thousands of volts from either earth to cloud, cloud to cloud, or from cloud to ground.

Mechanical Heat Energy

Frictional Heat - The heat generated by the movement between two objects in contact with each other.

Friction Sparks - The heat generated in the form of sparks from solid objects striking each other. Most often at least one of the objects is metal.

Heat of Compression - The heat generated by the forced reduction of a gaseous volume. Diesel engines ignite fuel vapor without a spark plug by the use of this principle.

Nuclear Heat Energy

Nuclear Fission and Fusion - The heat generated by either the splitting or combining of atoms.

3. THE BURNING PROCESS

The initiation of combustion requires the conversion of fuel into the gaseous state by heating. Fuel may be found in any of three states of matter: solid, liquid, or gas. Fuel gases are evolved from solid fuels by pyrolysis. This is defined as the chemical decomposition of a substance through the action of heat.

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Fuel gases are evolved from liquids by vaporization. This process is the same as boiling water or evaporation of a pan of water in sunlight. In both cases, heat caused the liquids to vaporize. No heat input is required with gaseous fuels and this places considerable restraints on the control and extinguishment of gas fuel fires.

4. CHARACTERISTICS OF FIRE BEHAVIOUR

Solid fuels have definite shape and size. One primary consideration with solid fuels is the surface area of the material in relation to its mass. The larger the surface area for a given mass the more rapid the heating of the material and increase in the speed of pyrolysis. The physical position of a solid fuel is also of great concern to fire fighting personnel. If the solid fuel is in a vertical position, fire spread will be more rapid than if it is in a horizontal position. This is due to increased heat transfer through convection and direct flame contact in addition to conduction and radiation.

Liquid fuels have physical properties that increase the difficulty of extinguishment and hazard to personnel. Liquids will assume the shape of their container. When a spill occurs, the liquid will assume the shape of the ground (flat) and will flow and accumulate in low areas.

The density of liquids in relation to water is known as specific gravity. Water is given a value of one. Liquids with a specific gravity less than one are lighter than water while those with a specific gravity greater than one are heavier in weight. It is interesting to note that most flammable liquids have a specific gravity of less than one.

The solubility of a liquid fuel in water is an important factor. Hydrocarbon liquids as a rule will not mix with water. Alcohols and polar solvents mix with water and if large volumes of water are used, they may be diluted to the point where they will not burn. Consideration must be given to which extinguishing agents are effective on hydrocarbons (insoluble) and which affect porous solvents and alcohols (soluble).

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The volatility or ease with which the liquid gives off vapor influences fire control objectives. The density of gas or vapor in relation to air is of concern with volatile liquids and with gas fuels.

Gases tend to assume the shape of their container but have no specific volume. If the vapor density of a gas is such that it is less dense than air (air is given a value of one), it will rise and tend to dissipate. If a gas or vapor is heavier than air, it will tend to hug the ground and travel as directed by terrain and wind.

The second phase in initiating combustion is the mixture of the fuel vapor with an oxidizer (air). The mixture of the fuel vapor and air must be within the flammable range. The upper and lower limits of concentration of vapor in air will allow flame propagation when contacted by a source of ignition.

The flammable range varies with the fuel and with the ambient temperature. Usually the flammable range is given for temperatures of 21°C.

EXAMPLES OF FLAMMABLE RANGES

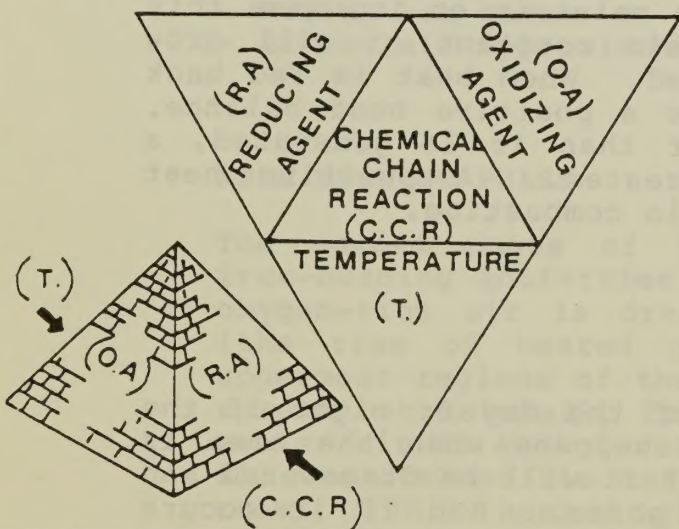
FUEL	LOWER LIMIT	UPPER LIMIT
Gasoline Vapor	1.4	7.6
Methane	5.0	17
Propane	2.2	9.5
Hydrogen	4.0	75
Acetylene	2.5	100

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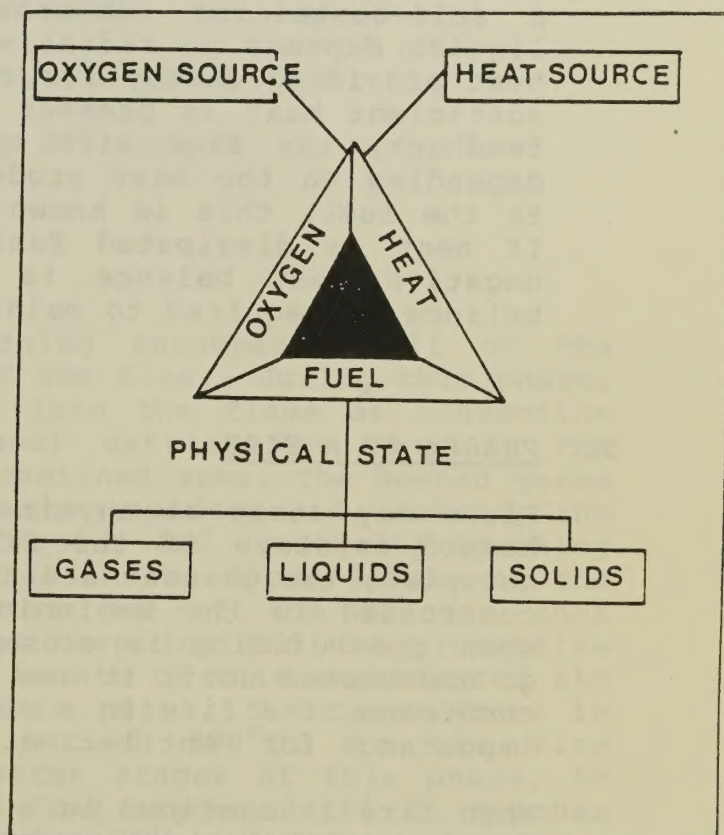
When the proper fuel vapor/air mixture has been achieved, it must then be raised to its ignition temperature.

Fire burns in two basic modes - flaming and/or surface combustion. The flaming mode of combustion represented by the fire tetrahedron (a four sided figure) with the four sides representing fuel, temperature, oxygen, and the uninhibited chemical chain reaction. The surface or smoldering mode of combustion is represented by the fire triangle with the three sides representing fuel, temperature and oxygen.

THE FIRE TETRAHEDRON



The fire tetrahedron includes the chemical chain reaction as component of burning, thus converting the fire triangle into a four-sided figure resembling a pyramid.



The fire triangle is used to explain the components necessary for burning to occur

(1986)

The fuel segment of both theories is any solid, liquid or gas that can combine with oxygen in the chemical reaction known as oxidation. Temperature is the measure of the molecular activity within a substance. A fuel with as sufficiently high temperature will ignite if an oxidizing agent is present. Combustion will continue as long as enough energy or heat is present. Under most conditions the oxidizing agent will be the oxygen in air, but the term helps explain how some materials that releases its own oxygen during combustion such as sodium nitrate and potassium chlorate can burn in an oxygen-free atmosphere. While scientists only partially understand what happens in a chemical chain reaction, they do know that heating produces vapors that contain substances that will combine with oxygen and burn.

A self-sustaining combustion reaction of solids and liquids depends on radiative feedback. This is radiant heat providing energy for continued vaporization. When sufficient heat is present to maintain or increase this feedback, the fire will remain constant or will grow depending on the heat produced. When heat is fed back to the fuel, this is known as a positive heat balance. If heat is dissipated faster than it is generated, a negative heat balance is created. A positive heat balance is required to maintain combustion.

5. PHASES OF A FIRE

Fires may start at anytime of the day or night if the hazard exists. If the fire happens when the area is occupied, the chances are that it will be discovered and controlled in the beginning phase. But if it occurs when the building is closed and deserted, the fire may go undetected until it has gained major proportions. The condition of a fire in a closed building is one of chief importance for ventilation.

When fire is confined in a building or room, a situation develops that requires carefully calculated and executed ventilation procedures if further damage is to be prevented and danger reduced. This type of fire can best be understood by an investigation of its three progressive stages:

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A firefighter may be confronted by one or all of the following phases of fire at any time; therefore, a working knowledge of these phases is important for understanding of ventilation procedures.

INCIPIENT PHASE

In the first phase, the oxygen content in the air has not been significantly reduced and the fire is producing water vapor (H_2O), carbon dioxide (CO_2), perhaps a small quantity of sulfur dioxide (SO_2), carbon monoxide (CO), and other gases. Some heat is being generated and the amount will increase with the progress of the fire. The fire may be producing a flame temperature well above $537^{\circ}C$, yet the temperature in the room at this stage may be only slightly increased.

- Room temperature slightly over $38^{\circ}C$
- Rising hot gases
- Rising air approximately 20% oxygen

FREE BURNING PHASE

The second phase of burning encompasses all of the free-burning activities of the fire. During this phase, oxygen-rich air is drawn into the flame as convection (the rise of heated gases) carries the heat to the uppermost regions of the confined area. The heated gases spread out laterally from the top downward, forcing the cooler air to seek lower levels, and eventually igniting all the combustible material in the upper levels of the room. This heated air is one of the reasons that firefighters are taught to keep low and use protective breathing equipment. One breath of this superheated air can sear the lungs. At this point, the temperature in the upper regions can exceed $700^{\circ}C$. As the fire progresses through the latter stages of this phase, it continues to consume the free oxygen until it reaches the point where there is insufficient oxygen to react with the fuel. The fire is then reduced to the smoldering phase and needs only a supply of oxygen to burn rapidly or explode.

(1986)

- Room temperature approximately 700°C
- Heat accumulates at upper areas
- Reduced oxygen supply - 16%

SMOLDERING PHASE

In the third phase, flame may cease to exist if the area of confinement is sufficiently airtight. In this instance, burning is reduced to glowing embers. The room becomes completely filled with dense smoke and gases to the extent that it is forced from all cracks under pressure. The fire will continue to smolder, and the room will completely fill with dense smoke and gases of combustion at a temperature of well over 537°C. The intense heat will have vaporized the lighter fuel fractions such as hydrogen and methane from the combustible material in the room. These fuel gases will be added to those produced by the fire and will further increase the hazard to the firefighter and create the possibility of a backdraft.

- Oxygen below 15%
- Temperature throughout is high
- CO and carbon may cause backdraft.

Backdraft

Firefighters responding to a confined fire that is late in the free-burning phase or in the smoldering phase risk causing a backdraft or smoke explosion if the science of fire is not considered in opening the structure.

In the smoldering phase of a fire, burning is incomplete because not enough oxygen is available to sustain the fire. However, the heat from the free-burning phase remains, and the unburned carbon particles and other flammable products of combustion are just waiting to burst into rapid, almost instantaneous combustion when more oxygen is supplied. Proper ventilation releases smoke and the hot unburned gases from the upper areas of

(1986)

the room or structure. Improper ventilation at this time supplies the dangerous missing link -- oxygen. As soon as the needed oxygen rushes in, the stalled combustion resumes; and it can be devastating in its speed, truly qualifying as an explosion.

Combustion is related to oxidation, and oxidation is a chemical reaction in which oxygen combines with other elements. Carbon is a naturally abundant element present in wood, among other things. When wood burns, carbon combines with oxygen to form carbon dioxide (CO_2), or carbon monoxide (CO), depending on the availability of oxygen. When oxygen is no longer available, free carbon is released in the smoke. A warning sign of possible backdraft is dense, black (carbon-filled) smoke.

The following characteristics may indicate a backdraft or smoke explosion condition:

- Smoke under pressure.
- Black smoke becoming dense gray yellow.
- Confinement and excessive heat.
- Little or no visible flame.
- Smoke leaves the building in puffs or at intervals.
- Smoke-stained windows.
- Muffled sounds.
- Sudden rapid movement of air inward when opening is made.

This type of condition can be made less dangerous by proper ventilation. If the building is opened at the highest point involved, the heated gases and smoke will be released, reducing the possibility of an explosion.

FLASHOVER

Flashover occurs when a room or other area becomes heated to the point where flames flash over the entire surface or area. Originally, it was believed that flashover was caused by combustible gases released during the early stages of the fire. It was thought that these gases collected at the ceiling level and mixed with air until they reached their flammable range, then suddenly ignited causing flashover.

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It is now believed that while this may occur, it precedes flashover. The cause of flashover is now attributed to the excessive build up of heat from the fire itself. As the fire continues to burn, all the contents of the fire area are gradually heated to their ignition temperatures. When they reach this point, simultaneous ignition occurs and the area becomes fully involved in fire.

6. HEAT TRANSFER

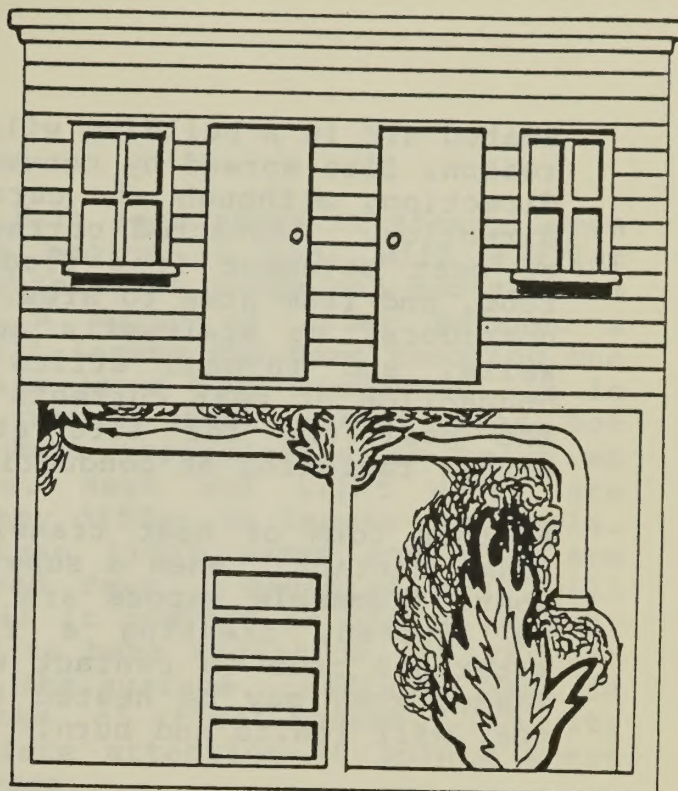
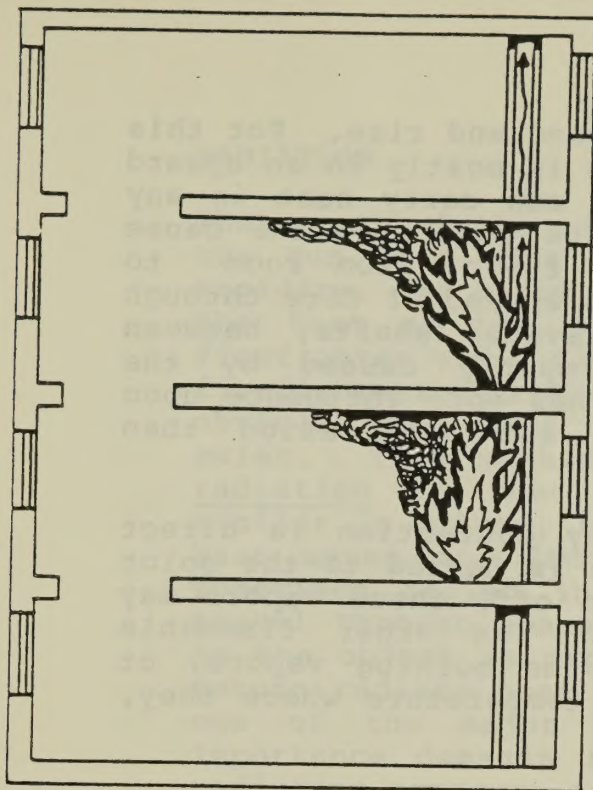
Heat can travel throughout a burning building by one or more of three methods, commonly referred to as conduction, convection, and radiation. Since the existence of heat within a substance is caused by molecular action, the greater the molecular activity, the more intense the heat. A number of natural laws of physics are involved in the transmission of heat. One is called the Law of Heat Flow; it specifies that heat tends to flow from a hot substance to a cold substance. The colder of two bodies in contact will absorb heat until both objects are the same temperature.

CONDUCTION

Heat may be conducted from one body to another by direct contact of the two bodies or by an intervening heat-conducting medium. The amount of heat that will be transferred and its rate of travel depends upon the conductivity of the material through which the heat is passing. Not all materials have the same heat conductivity. Aluminum, copper, and iron are good conductors. Fibrous materials, such as felt, cloth, and paper are poor conductors.

Liquids and gases are poor conductors of heat because of the movement of their molecules. Air is a relatively poor conductor. Certain solid materials when shredded into fibres and packed into batts make good insulation because the material itself is a poor conductor and there are air pockets within the batting. Double building walls that contain an air space provide additional insulation.

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Heat is transferred by conduction when an intervening medium carries the heat from floor to floor or room to room.

CONVECTION

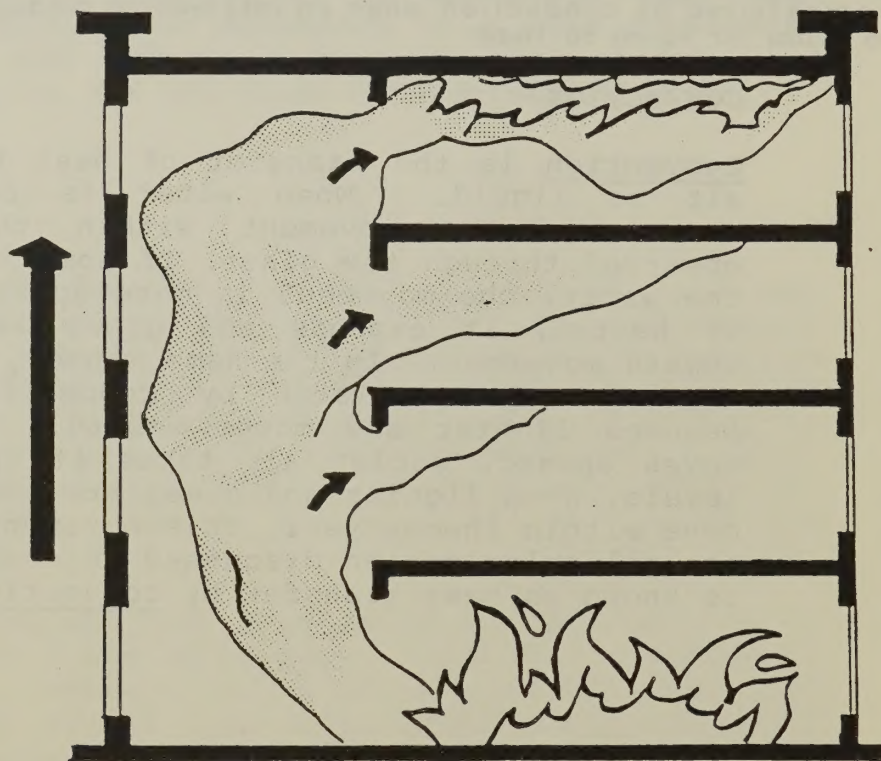
Convection is the transfer of heat by the movement of air or liquid. When water is heated in a glass container, the movement within the vessel can be observed through the glass. If some sawdust is added to the water, the movement is more apparent. As the water is heated, it expands and grows lighter, hence, the upward movement. In the same manner, air becomes heated near a steam radiator by conduction. It expands, becomes lighter and moves upward. As the heated air moves upward, cooler air takes its place at the lower levels. When liquids and gases are heated, they begin to move within themselves. This movement is different from the molecular motion discussed in conduction of heat and is known as heat transfer by convection.

(1986)

Heated air in a building will expand and rise. For this reason, fire spread by convection is mostly in an upward direction, although air currents can carry heat in any direction. Convected currents are generally the cause of heat movement from floor to floor, from room to room, and from area to area. The spread of fire through corridors, up stairwells and elevator shafts, between walls, and through attics is mostly caused by the convection of heat currents and has more influence upon the positions for fire attack and ventilation than either radiation or conduction.

Another form of heat transfer by convection is direct flame contact. When a substance is heated to the point where flammable vapors are given off, these vapors may be ignited, creating a flame. As other flammable materials come in contact with the burning vapors, or flame, they may be heated to a temperature where they, too, will ignite and burn.

UPWARD TRAVEL OF HOT GASES AS WITH AN OPEN STAIRWELL

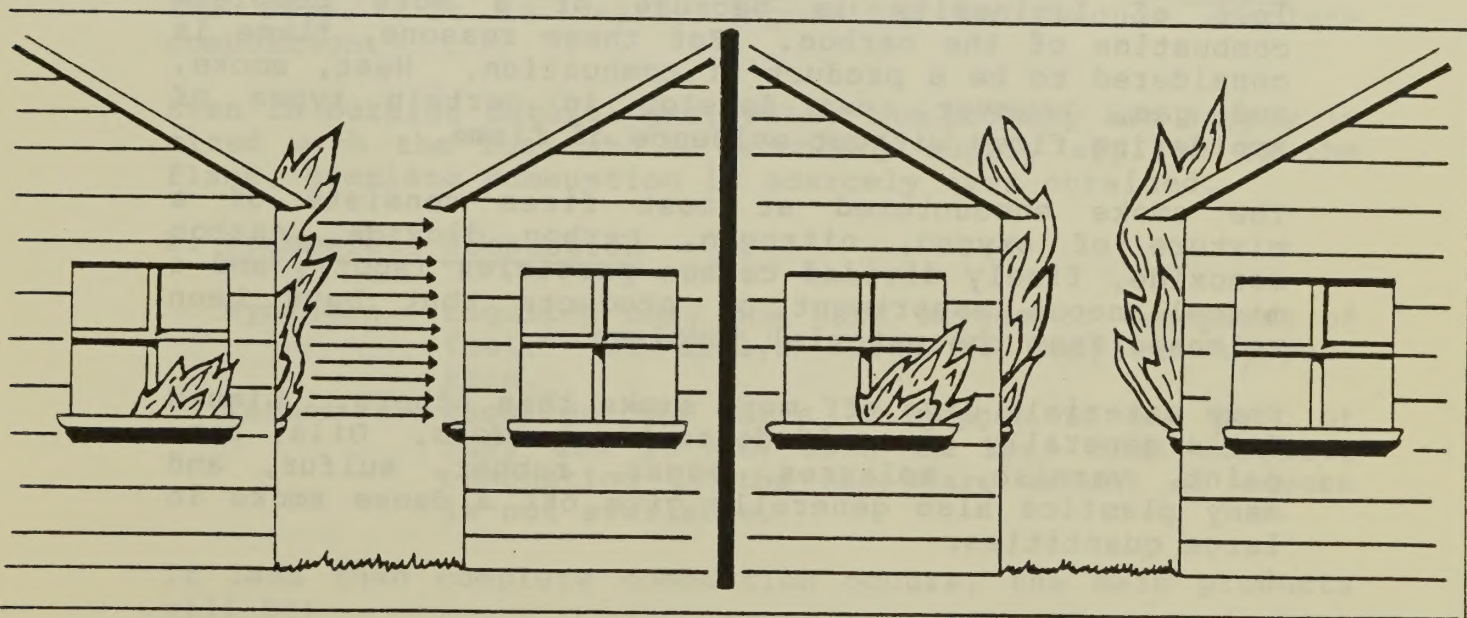


Heat is transferred by convection when air or water rise as they become heated.

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RADIATION

The warmth of the sun is felt soon after it rises. When the sun sets, the earth begins to cool with similar rapidity. We carry an umbrella to shade our bodies from the heat of the sun. A spray of water between a firefighter and a fire will lessen the heat reaching the firefighter. Although air is a poor conductor, it is obvious that heat can travel where matter does not exist. This method of heat transmission is known as radiation of heat waves. Heat and light waves are similar in nature, but they differ in length per cycle. Heat waves are longer than light waves and they are sometimes called infra-red rays. Radiated heat will travel through space until it reaches an opaque object. As the object is exposed to heat radiation, it will in return radiate heat from its surface. Radiated heat is one of the major sources of fire spread, and its importance demands immediate attention at points where radiation exposure is severe.



Heat is transferred by radiation when heat waves hit an object and heat it.

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7. PRODUCTS OF COMBUSTION

When a material (fuel) burns, it undergoes a chemical change. None of the elements making up the material are destroyed in the process, but all of the matter is transformed into another form of state. Although dispersed, the products of combustion equal in weight and volume that of the fuel before it was burned. When a fuel burns there are four products of combustion: fire gases, flame, heat, and smoke.

Heat is a form of energy that is measured in degrees of temperature to signify its intensity. In this sense, heat is the product of combustion that is responsible for the spread of fire. In a physiological sense, it is the direct cause of burns and other forms of personal injury. Injuries caused by heat include dehydration, heat exhaustion, and injury to the respiratory tract, in addition to burns.

Flame is the visible, luminous body of a burning gas. When a burning gas is mixed with the proper amount of oxygen, the flame becomes hotter and less luminous. This loss of luminosity is because of a more complete combustion of the carbon. For these reasons, flame is considered to be a product of combustion. Heat, smoke, and gas, however, can develop in certain types of smoldering fires without evidence of flame.

The smoke encountered at most fires consists of a mixture of oxygen, nitrogen, carbon dioxide, carbon monoxide, finely divided carbon particles (soot), and a miscellaneous assortment of products that have been released from the material involved.

Some materials give off more smoke than others. Liquid fuels generally give off dense black smoke. Oils, tar, paint, varnish, molasses, sugar, rubber, sulfur, and many plastics also generally give off a dense smoke in large quantities.

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COMPLETE AND INCOMPLETE COMBUSTION

Practically all combustible material consists of one or more of the following three fuel elements:

1. Carbon
2. Hydrogen
3. Sulphur

Of these three, the most commonly found are carbon and hydrogen.

1. Complete Combustion

As long as there is a sufficient supply of oxygen and the proper burning temperature is maintained.

- a. The Carbon burns - producing Carbon Dioxide
- b. The Hydrogen burns - producing Water Vapor
- c. The Sulphur burns - producing Sulphur Dioxide.

These gases heated to the temperature of combustion pass off into, and mingle with, the air that is supplying oxygen to the fire. It is nearly impossible to produce complete combustion.

Even in burning natural gas, where the primary air supply is mixed with the fuel and a secondary supply applied to the flame, complete combustion is scarcely ever obtained.

2. Incomplete Combustion

Hydrogen - requires only one part oxygen to two parts of fuel. It always burns to complete combustion.

Carbon - requires two parts of oxygen to one part of fuel and it can burn to less than complete combustion if the necessary amount of oxygen is not available.

If less than complete combustion occurs, the main products will be:

1. Smoke
2. Water vapor
3. Carbon Dioxide
4. Carbon Monoxide.

(1986)

8. FIRE EXTINGUISHMENT THEORY

The extinguishment of fire is based on an interruption of one or more of the essential elements in the combustion process. With flaming combustion the fire may be extinguished by reducing temperature, eliminating fuel or oxygen, or by stopping the uninhibited chemical chain reaction. If a fire is in the smoldering mode of combustion, only three extinguishment options exist: reduction of temperature, elimination of fuel, or oxygen.

EXTINGUISHMENT BY TEMPERATURE REDUCTION

One of the most common methods of extinguishment is by cooling with water. The process of extinguishment by cooling is dependent on cooling the fuel to a point where it does not produce sufficient vapor to burn. If we look at fuel types and vapor production, we find that solid fuels and liquid fuels with high flash points can be extinguished by cooling. Low flash point liquids and flammable gases cannot be extinguished by cooling with water as vapor production cannot be sufficiently reduced. Reduction of temperature is dependent on the application of an adequate flow in proper form to establish a negative heat balance.

EXTINGUISHMENT BY FUEL REMOVAL

In some cases, a fire is effectively extinguished by removing the fuel source. This may be accomplished by stopping the flow of liquid or gaseous fuel or by removing solid fuel in the path of the fire. Another method of fuel removal is to allow the fire to burn until all fuel is consumed.

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EXTINGUISHMENT BY OXYGEN DILUTION

The method of extinguishment by oxygen dilution is the reduction of the oxygen concentration to the fire area. This can be accomplished by introducing an inert gas into the fire or by separating the oxygen from the fuel. This method of extinguishment will not work on self-oxidizing materials or on certain metals as they are oxidized by carbon dioxide or nitrogen, the two most common extinguishing agents.

EXTINGUISHMENT BY CHEMICAL FLAME INHIBITION

Some extinguishing agents, such as dry chemicals and halons, interrupt the flame producing chemical reaction, resulting in rapid extinguishment. This method of extinguishment is effective only on gas and liquid fuels as they cannot burn in the smoldering mode of combustion. If extinguishment of smoldering materials is desired, the addition of cooling capability is required.

9. CLASSIFICATION OF FIRES AND EXTINGUISHMENT METHODS

CLASS A FIRES

Fires involving ordinary combustible materials, such as wood, cloth, paper, rubber, and many plastics.

Water is used in a cooling or quenching effect to reduce the temperature of the burning material below its ignition temperature.

CLASS B FIRES

Fires involving flammable liquids, greases, and gases.

The smothering or blanketing method of oxygen exclusion is most effective. Other extinguishing methods include removal of fuel and temperature reduction.

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CLASS C FIRES

Fires involving energized electrical equipment..

This fire can sometimes be controlled by a non-conducting extinguishing agent. The safest procedure is always to attempt to de-energize high voltage circuits and treat as a Class A or B fire depending upon the fuel involved.

CLASS D FIRES

Fires involving combustible metals, such as magnesium, titanium, zirconium, sodium, and potassium.

The extremely high temperature of some burning metals makes water and other common extinguishing agents ineffective. There is no agent available that will effectively control fires in all combustible metals. Special extinguishing agents are available for control of fire in each of the metals and are marked specifically for that metal.

NOTE: FOR ADDITIONAL INFORMATION, REFER TO I.F.S.T.A. MANUAL.

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CHAPTER 6

HOSE

1. INTRODUCTION

The term "fire hose" identifies a type of flexible tube used by firefighters to carry water under pressure from the source of supply to a point where it is discharged.

2. TYPES OF HOSE USED ON THE HAMILTON FIRE DEPARTMENT

- a) Double cotton jacket, rubber lined - 38mm, 65mm, 77mm
- b) Rubber covered, rubber lined 25mm, hard suction hose (helix coil inserted to withstand a vacuum)
- c) Synthetic jacket type - 100mm

NOTE: Unlined Linen Hose - is found in public buildings. Firefighters should not use unless necessary, as it leaks water and damage to the building will result.

3. HOSE DAMAGE

Causes of damage to fire hose are mechanical damage, mildew and mold, heat, contact with chemicals.

- a) Mechanical injuries are tears, abrasions caused by rough handling, dragging along the ground and traffic running over hose. This can be prevented by use of hose jumpers, hose rollers and abrupt pressure changes.
- b) Mildew and mold is caused by moisture. Wash and dry hose after use.
- c) Heat damage is prevented by protecting the hose from fire. It can also be protected by preventing excessive drying.
- d) Chemical contact should be prevented, and if hose does come in contact with chemicals, it should be washed thoroughly.

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Handling Frozen Hose

If the hose is frozen, avoid bending the hose unnecessarily, as damage to the fibres will result. This will break the threads and seriously harm the jacket. A good rule to follow is to handle frozen hose as little as possible.

4. TESTING HOSE

- a) Manufacture - all hose is tested by the manufacturer and bears the label of the Underwriters Laboratories Of Canada, and the words "Tested 2100 kPa to 4200 kPa."
- b) Hamilton Fire Department hose Testing - testing is done yearly or after repair.
 - 38mm, 65mm, and 77mm hose should be tested to 1400 kPa
 - 100mm hose should be tested to 700 kPa
 - expel all air from the hose by opening the nozzle with water flowing
 - close nozzle and raise pressure to above figure, hold for approximately 1 minute.
 - tag and mark any defect in hose or coupling.
 - Refer to Hose Testing Book for ADDITIONAL INFORMATION

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5. HOSE COUPLINGS

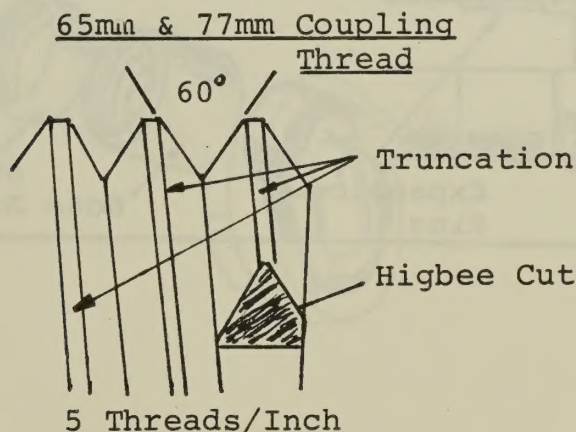
Couplings are constructed from:

- a) Brass (25mm, 38mm, 65mm & 77mm)
- b) Pyrolite (38mm, 65mm & 77mm).
- c) Aluminum (100mm).

NOTE: The pipe industry has not converted to the metric system; therefore, thread sizes are in Threads/Inch.

65mm & 77mm - screw type coupling.
- 5 threads per inch
- truncated threads
- higbee cut indicator.

Truncating - threads are cut in a "V" shape at a 60 degree angle.
- prevents binding.
- helps to clear grit from threads.

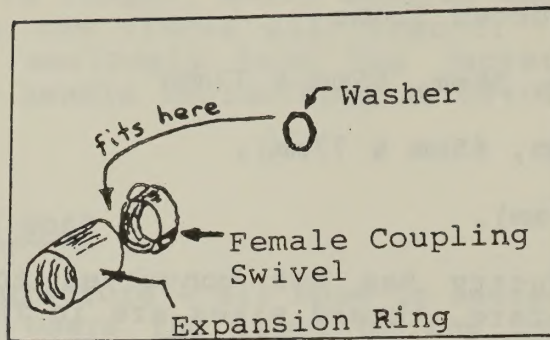


Higbee Cut - beginning of thread "cut to provide a positive connection between the first thread of opposing couplings.
- helps eliminate cross-threading.
- Higbee Cut Indicator is a notch or groove cut into the coupling lug to aid in identifying, both by sight and touch, the exact location of the Highbee Cut. When the indicator on the male coupling lug is lined up with the indicator on the female coupling lug, the threads are aligned for making the connection.

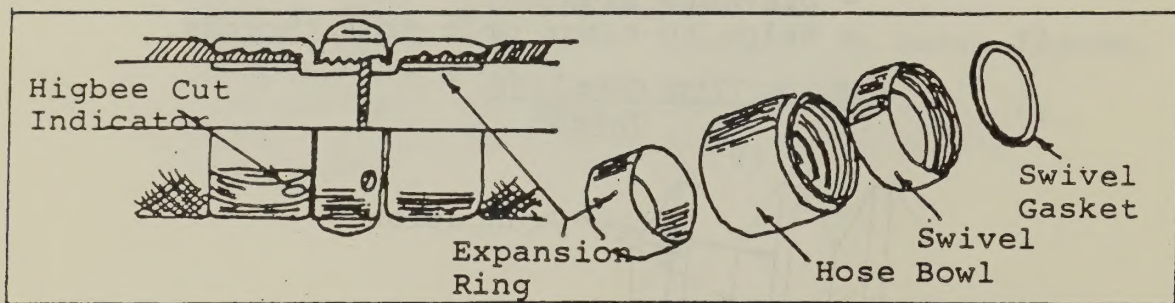
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HOSE COUPLING CONSTRUCTION

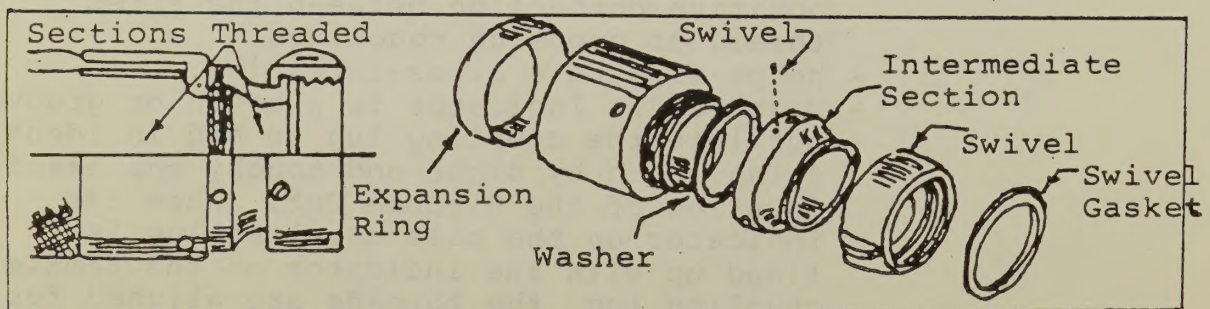
38mm



65mm



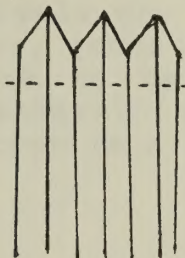
77mm



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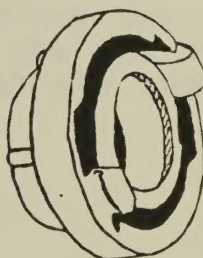
- 38mm - screw type coupling.
- 11-1/2 threads per inch
 - no higbee cut indicator.
 - no truncation of threads.

38mm Coupling
Thread



11½ Threads/Inch

- 100mm - Stortz type couplings.
- quick-connect (quarter turn).
 - lightweight aluminum (2 kgs.).
 - no male or female connections - couplings are identical.



NOTE: All HFD hose couplings are to be key tightened.

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- show type coupling
- 11-1/2 inches per inch
- no signs of distortion
- no separation of threads



THE UNIVERSITY OF CHICAGO

- show type coupling
- 11-1/2 inches per inch
- no signs of distortion
- no separation of threads



NOTE - 11-1/2 inches per inch

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Recommendations For Care of Couplings:

In the area of preventing damage to hose couplings, undue, careless or rough handling is to be avoided, injuries to the threads render the hose inoperative. Examine the hose couplings for damage after use and have any defective coupling repaired. Swivels may be cleaned by spinning them in a pail of soapy water, grease and oil are not to be used. Worn rubber gaskets are to be replaced. Each apparatus carries a supply of washers. Do not use undue force when making connections, except in a hard suction hook up.

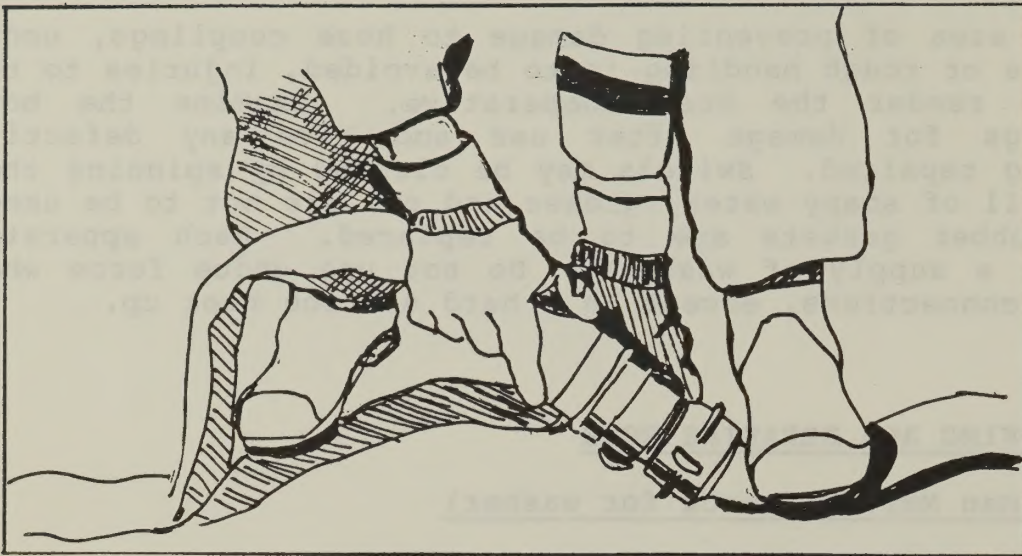
6. MAKING AND BREAKING HOSE

1 Man Making (check for washer)

a) Coupling Hose (Foot-Tilt Method)

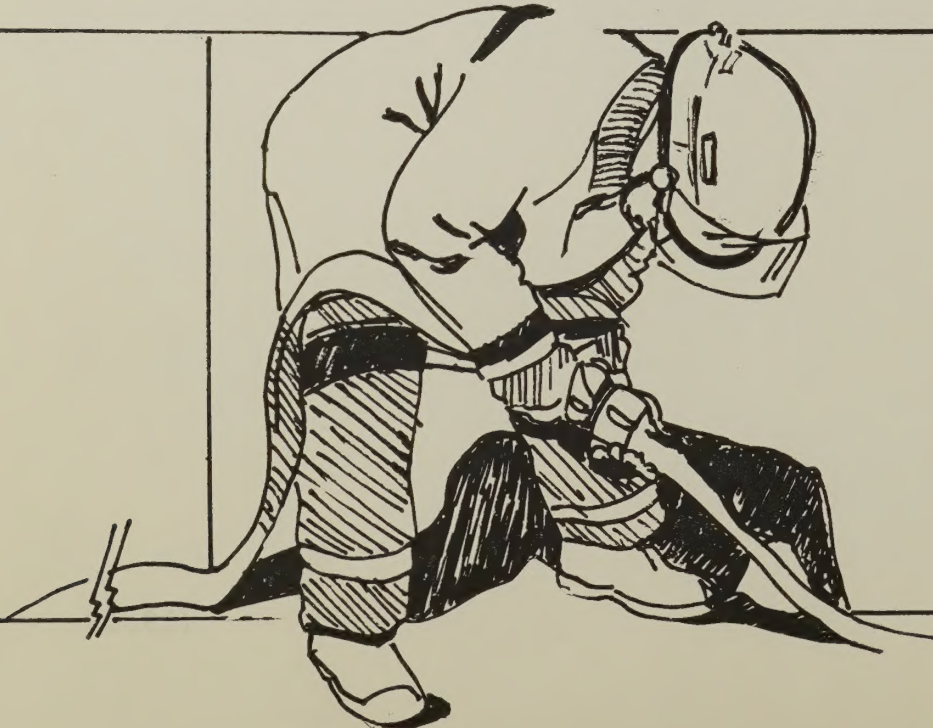
Stand facing the two couplings so that one foot is near the male end. Place the foot directly behind the male coupling and apply pressure to tilt it upward. Position the feet well apart for balance, grasp the female end with one hand behind the coupling and place the other hand on the coupling swivel. Bring the two couplings together and turn the swivel with the thumb of the hand to make the connection.

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b) Coupling Hose (Over-The-Hip Method)

Grasp the female coupling with one hand on the swivel. The hose is brought across the hip with the feet spread comfortably apart. Allow the female coupling to hang about 1/3 of a metre over the hip toward the ground. Pick up the male coupling with the other hand, align the couplings, and turn the swivel to engage the threads.

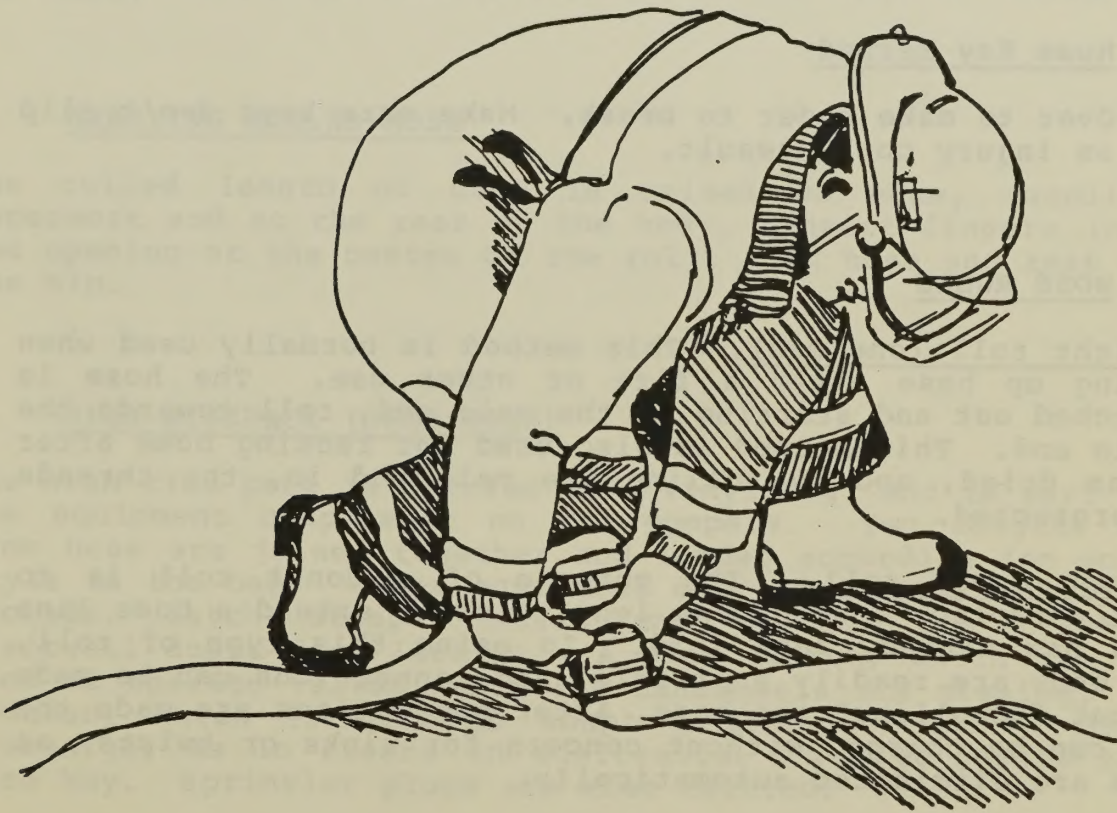


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1 Man Breaking

- a) Use one armed fireman mounted on rear of pumps.
(male end in holder)
- b) Knee-Press Method

Grasp the hose behind the female coupling and stand the connection on end with the male coupling below. Best results will be obtained if the hose is bent close to the male coupling. Set the feet well apart for balance, and place the right knee upon the hose and shank of the female coupling. Keep the thigh in a vertical plane with the couplings and apply body weight to the connected coupling. As this weight is applied, quickly snap the swivel in a counterclockwise direction.



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2 Man Making (check for washer)

- a) When two firefighters couple hose, the operator of the female coupling swivel aligns the hose. (use higbee indicators on 65mm and 77mm hose). Key tighten 65mm and 77mm hose. "Key tighten all hose".

2 Man Breaking

a) Stiff-Arm Method

Two firefighters face each other with the hose coupling between them. Each firefighter takes a firm two-handed grip on their respective coupling and presses the coupling toward each other thereby compressing the gasket in the coupling. Keeping their arms stiff, and elbows out, both firefighters use the weight of their bodies to turn the hose coupling counterclockwise.

b) Hose Key Method

Over to make under to break. Make sure keys don't slip as injury could result.

7. HOSE ROLLS

Straight roll (one man). This method is normally used when picking up hose after a fire or other use. The hose is stretched out and starting at the male end, roll towards the female end. This method is also used for racking hose after it has dried, and by rolling the male end in, the threads are protected.

One man donut roll. The purpose of a donut roll is to quickly replace broken hose lengths or to extend a hose line which has already been laid. In using this type of roll, both ends are readily available, and connections can be made without "unrolling" the hose. After connections are made the hose can be charged without concern for kinks or twists, as these are eliminated automatically.

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When only one man is available, the hose to be rolled is stretched out, and the person to do the rolling judges approximately the centre of the hose. Straddle the hose and move at least 1m toward the male end, then turn and face the female end. The person rolling bends and makes a small loop in the hose, folds it over in the direction of the female end, and the hose is then rolled toward the female end.

Note: Generally the making of a donut is a two man job.

Two man donut: The hose to be rolled is stretched out and then doubled by walking the male end toward the female, and placing it at least 1m from the female. One man takes his position at the folded end and while the other straddles the hose facing in the opposite direction. With the two, straddling the hose and facing each other, the hose is now rolled in the direction of the ends. The person walking backwards removes the slack as the one walking forward rolls the hose.

8. CARRYING ROLLED HOSE

The rolled length of hose is raised on edge, coupling uppermost and to the rear of the body. Insert fingers into the opening at the centre of the roll, lift hose and rest on the hip.

9. HIGH-RISEPACK (38mm HOSE)

The high rise pack is carried in a vinyl bag, and is part of the equipment compliment on all pumpers. Two lengths of 38mm hose are joined together and loaded accordin (on end) style in the bag. Other equipment carried in the pack will include, latch straps, which can be used to prevent stairwell doors from locking. A pipe wrench, which can be used to operate valves where the handwheels are missing. A reducer, which is used to adapt a 65mm port to a 38mm discharge, as in risers in stairwells. A 38mm nozzle and hose key. Sprinkler plugs are also carried.

Note: Where a working fire is expected, use our own hose and appliances, as firefighting equipment in many buildings should not be trusted.

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Loading The Highrise Pack (Wooden Loading Box Found In All Stations)

1. Join two lengths of 38mm hose.
2. Attach reducer to female coupling and place at right hand open end of wooden box. Lay hose on bottom layer of box accordian style until bottom layer is full, working right to left.
3. Bring hose up to second level and work left to right until all hose is used.
4. Connect nozzle to male coupling of hose. Both reducer and nozzle are now on the same side of box.
5. Slide wooden box into highrise pack (open end first). Remove wooden box leaving hose inside of highrise pack. Secure pack.

10. HOSE CLAMPS

A hose clamp is a device which is used to stop the flow of water in a hose line when a burst length must be replaced, or a line must be lengthened. This is a valuable tool in these cases, as it eliminates the need to shut down the pumper, or at least that discharge port. The two types of hose clamps used on the H.F.D. are the Hebert and the Akron.

Note: Open and close hose clamps slowly to avoid water hammer.

11. HIGH VOLUME 100mm HOSE

The H.F.D. has adopted 100mm large diameter hose, and related appliances for special applications, and as an option for the company officer who's responsibility it is to supply water in a given situation.

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The H.F.D. uses 100mm hose in 30m lengths, equipped with the "Stortz" type coupling. This coupling is compatible with the adapters which are used for special application, such as portable hydrants, steamer port adapters, etc. The Stortz coupling is very light in weight, is a quick connect design, (quarter turn) and both ends are identical, that is, no male or female ends.

The hose is a rubber lined, single jacketed design of 100% woven synthetic material. It will not mildew or absorb water, and it requires no drying. It is easy to clean as well as being resistant to sparks and heat, etc. The cover can be restored if damaged, and in cold temperatures it remains flexible at 4°C. The most important feature of all is that it can move large volumes of water, long distance, at low pressures and friction loss.

Important notes regarding 100mm hose are:

1. Either empty or charged, it must not be dragged if at all possible. This point applies to any single jacketed hose.
2. Charge slower.
3. Lay slower
4. Take out twists before charging.

100mm hose may be used for the following:

As a supply line from a hydrant to a pumper,

As a relay line between pumpers,

As a delivery line from a pumper to a large volume master stream device.

ADDITIONAL ADVANTAGE OF 100mm HOSE

A drastic reduction in friction loss.

Reduces manpower, as the need for one line instead of several siamesed lines is a great advantage.

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The danger of accidents is reduced, as fewer lines reduce the "spaghetti" effect and minimize the possibility of tripping.

Time is saved both when laying the hose and when picking up.

Fewer pumps are required for long lays, or high volume requirements, as a high volume with drastically reduced friction loss reduces the pressure at each pump.

12. HOSE LOADS

The loading of hose on the apparatus is not an emergency operation, yet it is a very vital operation that must be done correctly so that at a time of emergency firefighting operations, can be carried out efficiently. All 65mm and 77mm hose loads are now loaded on the apparatus in the reverse lay, with a double female attached to the last male coupling. This type of load provides easier coupling to any piece of equipment, i.e.- aerial, snorkel, standpipe, etc., as well as catching a hydrant.

Flat Load

38mm, 65mm, 77mm, 100mm are loaded in this fashion on pumpers.

A flat load consists of folding the hose back and forth lengthwise in the hose bed with the flat side down. Care should be taken to stagger the layer at the end of the load so that the folds will not be one upon the other. Should the ends be kept even, the ends of the load will fill faster than the centre and cause the hose to fly up when being layed.

Equipment Secured To Each Load

a) 38mm Load - Nozzles

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b) 65mm Load - Double Female

- Hydrant kit consisting of a strap, adjustable key, gate valve
- In Winter - 1 Winter Hydrant Key

c) 77mm Load - Double Female

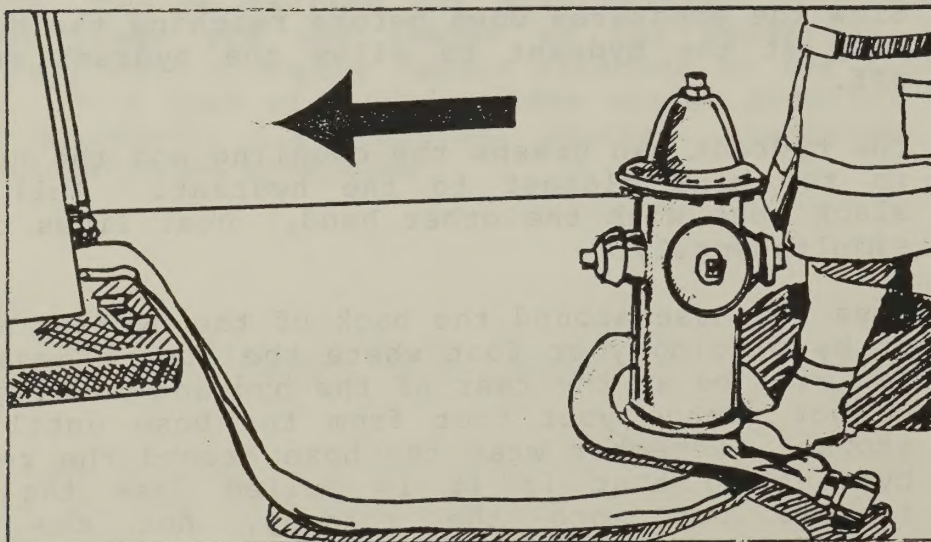
d) 100mm Load - Strap, 2 keys (adjustable, 100mm key), gate valve, 100mm - 115mm steamer port adapter, 65mm -100m stortz adapter.

13. CATCHING A HYDRANT

1. Slow the apparatus down before reaching the hydrant and stop at the hydrant to allow the hydrant man to get off.
2. The hydrant man grasps the coupling and the hydrant kit in the hand closest to the hydrant. Pull off some slack hose with the other hand. Dual lines catch both simultaneously.
3. Pass the hose around the back of the hydrant and anchor it by placing your foot where the hose crosses itself. You will be at the rear of the hydrant looking forward. Do not remove your foot from the hose until the pump stops. *Remember wrap the hose around the rear of the hydrant so that if it is pulled free the butt end travels out into the roadway, not the sidewalk, preventing injury to you or others.

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4. Make sure the hydrant is in the off position. Take the caps off the hydrant and hook-up the gate valve and hose. Hook-up the hose to the port closest to the direction that the pump has proceeded to. It is good practice to connect the gate valve first. This will eliminate any possibility of the hydrant being turned on before the gate valve is connected. Place the hydrant key on the spindle so you are ready to supply water.
5. When signalled to open the hydrant, the key is turned "Clockwise". The left hand is placed on the spindle and the right hand on the key. Open fully.



14. HYDRANT CONNECTIONS

Note:

The size of the main feeding the hydrant will dictate water supply. All hose lays below, from hydrant to the pumper were 90m long. ALWAYS wait for signal from pump driver before charging each line.

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- (a) 65mm only
- 1st connect gate valve to 65mm port farthest away from the fire.
 - 2nd connect 65mm hose to 65mm port closest to the fire.
 - 1,100 litres of water was supplied.
- (b) Parallel lines - 65mm and 77mm
- 1st connect gate valve to 65 mm port farthest away from fire.
 - 2nd connect 65mm hose to 65mm port closest to fire
 - 3rd connect 77mm hose to gate valve.
 - 2,900 litres of water was supplied.
- (c) 100mm only
- 1st connect gate valve to 65mm port farthest away from the fire.
 - 2nd connect 100mm hose to hydrant steamer port.
 - 2,800 litres of water was supplied.
- (d) 100mm and 77mm
- 1st connect gate valve to 65mm port farthest away from fire.
 - 2nd connect 100mm hose to hydrant steamer port.
 - 3rd connect 77mm hose to gate valve
 - Use same procedure if 65 mm hose is substituted for 77 mm hose
 - 3,900 litres of water was supplied.
- (e) Soft suction Hook Up - Explained later in chapter
- 5000 litres of water was supplied.
- (f) 100mm (using 100mm to 65mm adapter)
- use these adapters only if steamer port connections are not possible.

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15. COLOUR CODING OF FIRE HYDRANTS

CLASS	FLOW	COLOUR OF CAPS
A	3800 litres or greater	Green
B	1900 litres - 3800 litres	Orange
C	Less than 1900 litres	Red

16. HOSE LAYS

Successful application of fire streams is largely dependent on the speed and efficiency of pump companies laying hoselines and connecting to a water supply. Hose beds should be arranged to facilitate the laying of either single or multiple hoselines.

- a) STRAIGHT LAY (HYDRANT TO FIRE) - This operation consists of stopping the apparatus at the water supply source and permitting the hydrant person to safely leave the apparatus and secure the hose, after which the apparatus proceeds to the fire laying either single or dual lines of hose.

NOTE: IF A WATER SOURCE IS NOT SECURED BY THE FIRST ARRIVING PUMP COMPANY, THAT COMPANY MUST RADIO TO THE SECOND ARRIVING PUMP TO CATCH A HYDRANT ON THE WAY IN AND SUPPLY THE FIRST PUMP WITH WATER "USE THE RADIO".

- b) REVERSE LAY (FIRE TO HYDRANT) - Sometimes it is necessary to place fire apparatus at the source of water supply to feed the hoselines with adequate pressure and volume. This operation makes it necessary for the pumper to lay hoselines in reverse (from the fire to the water source). This lay on the Hamilton Fire Department will be mainly used on multiple alarms. There are many variations of this lay. Examine this one example:

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- i) Hydrant man wraps 65mm and 77mm hose around hydrant (do not hook up).
- ii) Pump proceeds to fire area laying the above double lines.
- iii) Remove all extra hose, nozzles, deck gun masks, etc. Remember to remove extra 65mm and 77mm hose as you will be feeding aerials, snorkel, deluge sets. (Double male adapters will be necessary).
- iv) Pump is turned around and 65mm hose is reversed layed back to the hydrant. Officer and nozzle men remain at fire scene.
- v) Pump goes into soft suction hook-up (explained later in chapter). Three lines are now ready to be charged.

17. SOFT SUCTION HOOK-UP

The soft suction hook-up requires only the services of two men, that of the hydrant man and the driver. For clarity and drill the men will be given numbers in the following manner:

- #1 - Hydrant Man
- #2 - Nozzle Man (not required in the evolution except to lay lines).
- #3 - Driver

Duties of Assigned Positions

- (a) #3 man will be responsible for the positioning of the apparatus in a manoeuvrable position approximately 3m back and 3m out from the hydrant.
- (b) #3 man will shut off the booster tank, remove the port cover or Stortz gate valve on the operational side of the pumper, then assist #1 man.
- (c) #1 and #3 men remove and carry the soft suction to the operational side of the pumper.
- (d) #3 man will proceed to attach it to the suction port on the pumper and #1 man will assist.
- (e) #3 man will return to the cab.
- (f) #1 man carrying the soft suction and a hydrant key, will direct the driver as he locates his pumper at the hydrant, leaving a minimum of slack in the suction hose when finally it is attached to the hydrant.
- (g) #1 man upon attaching the soft suction to the hydrant will turn the hydrant on.

(1986)

- (h) #3 man will immediately place suction stand under the soft suction to support it, after making his pump ready for operation. In an efficient operation, the #3 man should accomplish this task in co-ordination with the #1 man so that the suction will be supported as the water is turned on.
- (i) #1 man is now available for fireground duties, and #3 man will now carry out pump operations to supply water through the lines to the fire.

Note: Safety:

Never walk backwards when hooking up soft suction.

18. HARD SUCTION HOOK-UP

The hard suction hook-up requires the services of 3 men. For clarity of this evolution the men will be given numbers in the following sequence:

- #1 - Hydrant Man
- #2 - Nozzle Man
- #3 - Driver

Duties of Assigned Positions

- a) #3 man will be responsible to position his apparatus at an approximate 45° angle to the water, allowing sufficient space (6m) between pumper and water to permit free movement of personnel. After positioning of apparatus, #3 man will shut off the booster tank and remove the suction port cover or stortz gate valve and place in a safe location.
- b) #1 man will get the suction screen.
- c) #2 man will unlock both suctions and push out the desired suction to facilitate the attachment of the screen by #1 man.
- d) #1 man will attach the suction screen.
- e) #1 and #2 men will now remove the one suction length and carry it upon their shoulders to the rear of the apparatus.

(1986)

- f) #3 man will push out the remaining suction so that the end is clear of the suction rack.
- g) #3 man will now hold the suction on the rack while #2 man joins the two suction lengths. (Hand pressure will be used on hand lug couplings, keys will be used, ONLY on couplings so designed for keys.)
- h) All three men will now carry the joined suctions on their shoulders to the selected side of apparatus, placing it at right angles to the suction port.
- i) #1 man places his end (screen) on the ground and takes up a position between #2 and #3 men and assists #3 man to attach the suction. #2 man will support the suction on his knee in line with the suction port. #3 man will attach the suction to the pump suction port.
- j) All 3 men will now assume their original positions.
- k) #1 and #2 men will carry the suction ahead of the apparatus while #3 man, under the guidance of the Officer in charge, drives the apparatus to a position at the water edge. Care must be taken that the suction couplings are tight and not placed on the edge of a break wall or pier. This could cause an air leak and prevent a proper prime. To ensure the tightness of hard suction couplings, use the rubber mallet provided for this purpose.
- l) #3 man will apply the securing brakes and engage his pump; then he places the wheel blocks under the rear wheels and then places the suction stand.
#2 man places the chaffing pad in position.
#1 man secures the strainer rope to a solid object.
- m) The pump is now ready for operation and #1 and #2 men can now lay hose lines to the fire.

19. ADVANCING HOSE

There are several methods that may be employed to advance either 77mm, 65mm and 38mm hose. Fire conditions, such as distance to be travelled or building to be scaled will dictate the method or methods to be practiced.

(1986)

65mm Hose Empty - 1 Man

To enable one man to advance 65mm hose with relative ease, no more than 30M will be advanced in a straight lay, in any one movement.

The following sequence will be used for Reverse Load.

- a) Remove 65mm double female (if attached) and apply nozzle to hose.
- b) Facing the apparatus, place the hose across the chest, then over the shoulder with the nozzle resting in the small of the back.
- c) About turn and advance straight out 30M and place nozzle and hose on the ground.
- d) Return to the apparatus, take a second bite of hose and once again advance 30M. This will now cause a series of "V's" of hose to be layed out on the ground. This evolution may be repeated as often as required, so that the necessary amount of hose is removed from the apparatus.
- e) "V's" of hose are now advanced in sequence starting at the main line of hose coming from the pump and working to the nozzle.
- f) The completion of this evolution will now have permitted one man to advance long lays of hose as illustrated.

NOTE: This method of advancing hose can be used to advance any size of hose to any appliance or apparatus as required. (Determine the need before hand, to see if the double female is required before advancing the hose).

(1986)

Advancing 38mm and 65mm Hose Up A Ladder

The method of advancing 38mm and 65mm hose up a ladder is basically the same. When advancing 38mm hose, a man is placed at each coupling while in the 65mm advance, a man is placed at the 8m mark and one at the coupling.

1. Advance the hose to the base of the ladder in the previously described manner, with the nozzle or coupling resting in the small of the back.
2. Upon reaching the base of the ladder, place the nozzle over the shoulder OPPOSITE the WORKING SIDE of the ladder. The hose will then cross the nozzle man's chest and lay down the working side of the ladder. Care must be taken to ensure EACH man takes a hose strap.
3. The second man steps in at the 15m mark for 38mm hose, 8m mark for 65mm hose, and places the hose over the shoulder nearest the working side of the ladder with the coupling to the front. Taking a hose strap with him, he now begins to climb the ladder maintaining a distance of 3m between each man with the hose hanging down the working side of the ladder.
4. The procedure in #3 is repeated as often as required.

NOTE: Working side - side of the ladder on which the work is performed.

- charged lines will lay on the ladder not off the side.

Advancing Pre-connected 38mm Banks (1 Man)

30 Metre Bank

- 1) Facing the apparatus place the hose across the chest, then over the shoulder with the nozzle resting in the small of the back.

(1986)

- 2) About turn and advance to the fire.

60 Metre Bank

- 1) Facing the apparatus place the hose across the chest, then over the shoulder with the nozzle resting in the small of the back.
- 2) Grasping the entire hose load with both hands remove the hose from the transverse bed and drop the hose to the ground keeping the hose load intact.
- 3) About turn and advance to the fire.

90 Metre Bank

- 1) Facing the apparatus place the hose across the chest, then over the shoulder with the nozzle resting in the small of the back.
- 2) Grasping the upper half of the hose load with both hands remove the hose from the rear bed and step well back in the direction of travel laying the hose on the ground.
- 3) Repeat step 2 pulling off the bottom half of the load in the same manner and placing it behind the first lengths of hose on the ground in the direction of travel.
- 4) Return to nozzle and advance in the direction of the fire.

NOTE: When loading the 30, 60 and 90 metre beds, load in a manner so that the single bottom row that is pre-connected to the discharge port is set back from the edge so that it cannot be grabbed when unloading the hose. This will stop the firefighter from pulling on this lay making it easy to drop hose to the ground.

(1986)

Advancing Hose On Ground Level - 2 or more men (empty line)

The same evolutions are performed as for advancing up a ladder with the exception that no hose strap is required. If there is a shortage in man power, the 1 man advance should be used.

20. HOISTING AN EMPTY LINE WITH A NOZZLE ATTACHED 38mm AND 65mm

1. The nozzle is folded over on the hose and the hose folded once more.
2. A rope is dropped from the roof or window. A running bowline is then tied 1m back from the fold.
3. Two half hitches are then tied on the folded hose and the line hoisted.

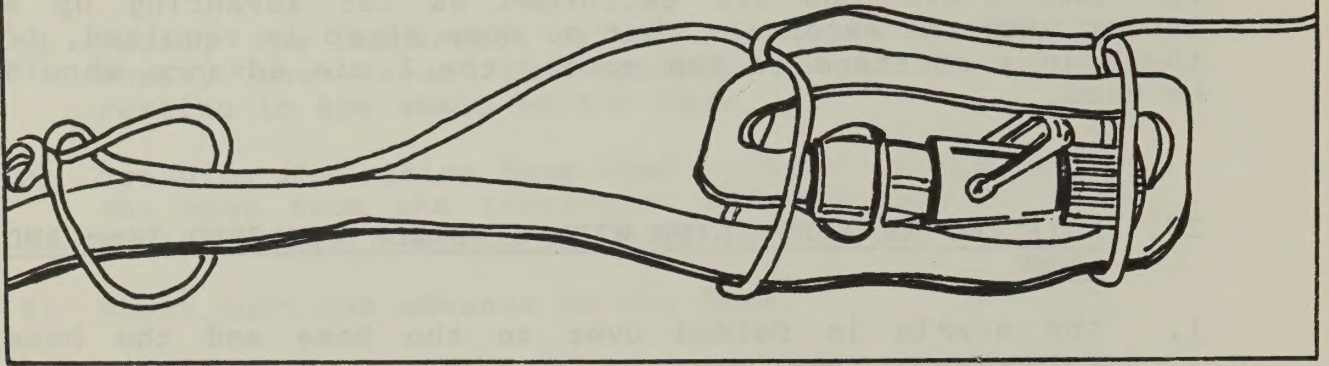
Hoisting A Loaded Line - Nozzle Attached

1. Rope is dropped from roof or window and a running bowline is tied 1m back from the nozzle.
2. Tie a series of half hitches on the hose and on the nozzle.
3. A half hitch is tied at the base of the shut off of the nozzle to prevent it from opening while being hoisted.
4. The line is hoisted.

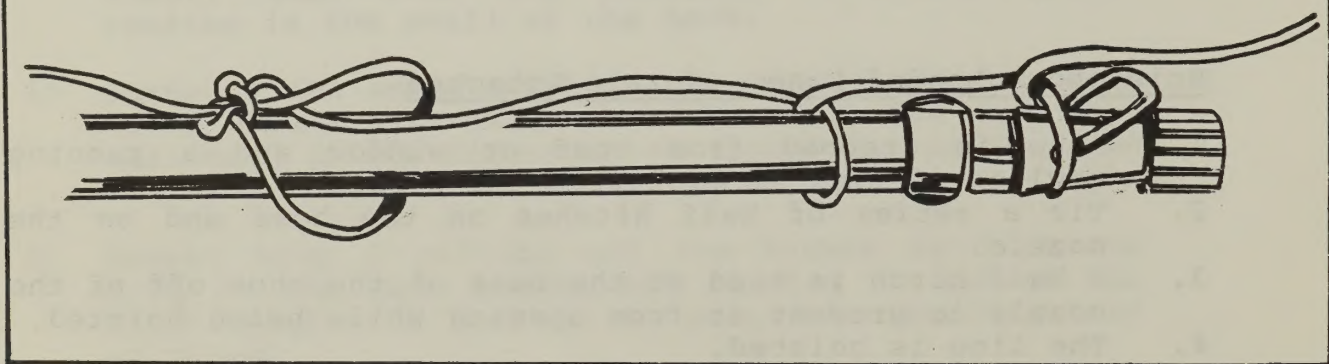
NOTE: Where a cornice roller is available, it should be used.

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Empty Line



Loaded Line



21. 65mm LOADED LINE

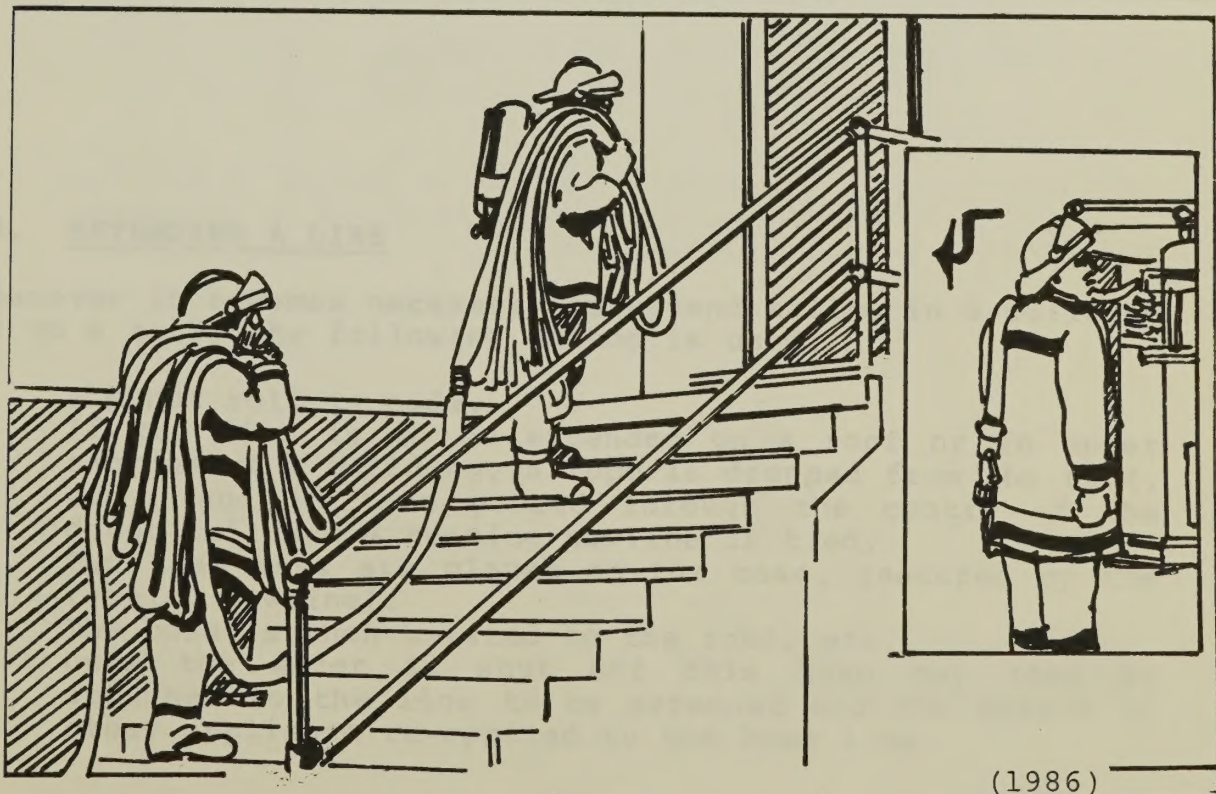
The following method may be employed to remove the slack from hose that has been layed and charged. One or more men may be used, this will depend upon the various conditions present at the time.

- a) Gather sufficient hose and form a loop or donut. The size of the loop formed will be governed by the amount of hose required to be straightened and the number of men available to do the job.
- b) Stand the loop on edge and roll in the direction of the nozzle.

(1986)

22. SHOULDER LOAD - 38mm Hose Advanced Up A Stairway, etc.

1. The driver stands on the tailboard while the nozzleman stands on the ground facing him.
2. The driver places the nozzle over the nozzleman's shoulder nearest the fire so that the nozzle is resting in the small of the back.
3. The driver places the hose on the open shoulder to knee level. (i.e., if the nozzle is placed on the right shoulder, the left shoulder is the open shoulder). The nozzleman then turns and steps 10 to 15 paces towards the fire or building in order for the second man to be loaded with hose. (If Two Man Evolution).
4. If a second man is required, he also faces the driver, and is loaded on the shoulder opposite the fire in the prescribed manner.
5. Both men now advance up the stairway, etc., and when the second man feels tension on the line, he drops off one fold of hose, and carries on etc. Lay the hose on the stairs against the outside wall to avoid sharp bends and kinks.
6. If more than 1 man is required to advance the shoulder load, the LAST man to enter the building is the first man to drop off his shoulder load of hose. (Nozzleman should be the last to drop hose load).



(1986)

23. ADVANCING 65mm HOSE TO FRONT OF THE APPARATUS

1. Approximately 15M of hose (2 bites in each hand) is pulled clear of hose bed (1A) and laid to the side of the apparatus (opposite fire if possible) maintaining the flat load (1B).

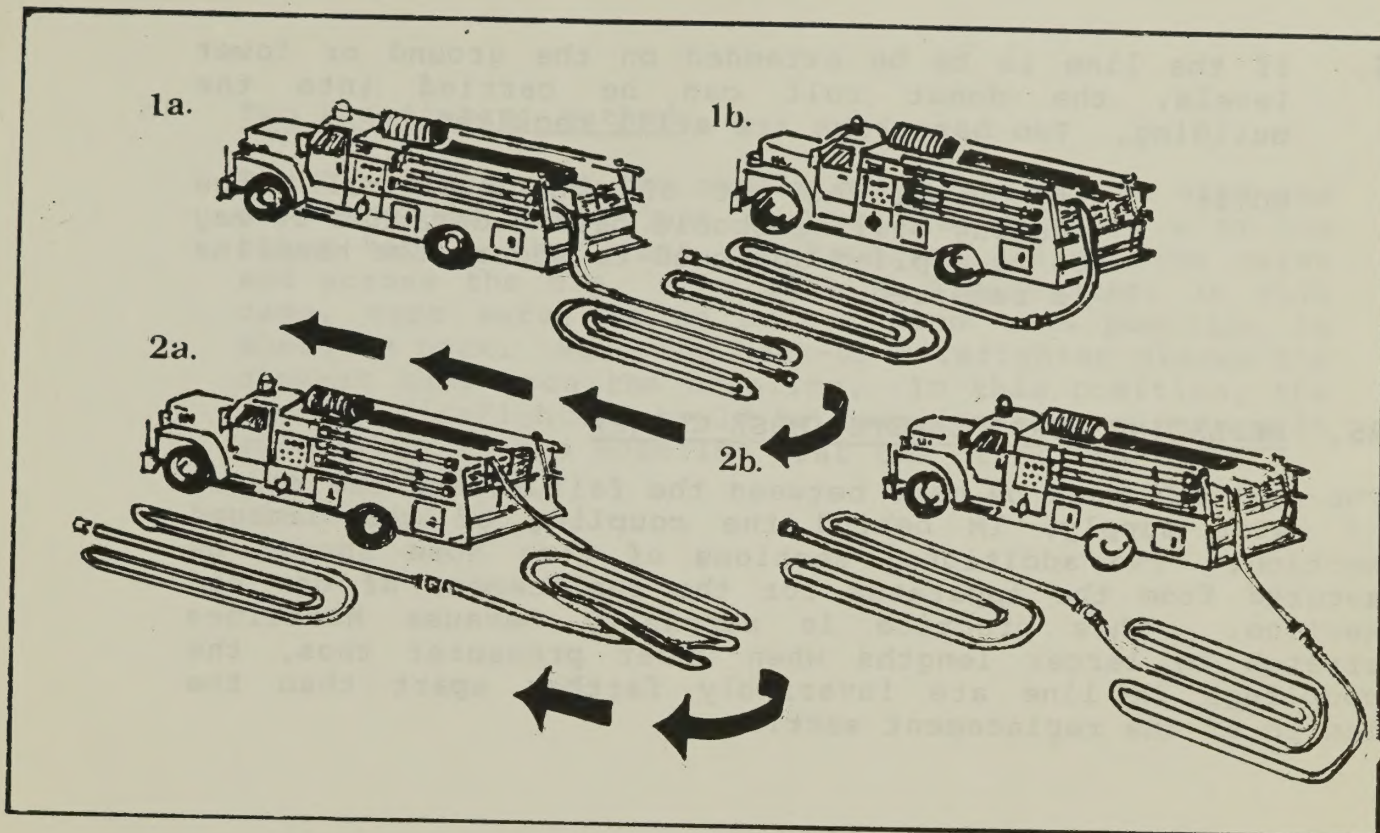
NOTE: If the 65mm hose is to be used with a nozzle or connected to an Aerial, Snorkel, Deluge, Sprinkler Connection, etc., the double female connection must be removed.

2. A second pull of approximately 15M (2A) is then laid behind the first lay, maintaining the flat load (2B).
3. With approximately 30M of hose clear of the apparatus it now may be advanced starting at the butt end.
4. If more hose is required to complete the lay, repeat the above steps.

NOTE: 38mm and 77mm hose may be advanced in the same manner as above.



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24. EXTENDING A LINE

Whenever it becomes necessary to extend a line in a building or on a roof, the following method is used.

1. A donut roll is made.
2. If the line is to be extended on a roof or in upper stories of a building, a rope is dropped from the roof, etc., and is then passed through the centre of the donut roll and a running bowline is tied.
3. Two hose keys are placed on the hose. (secured by the running bowline).
4. The hose is then hoisted to the roof, etc.
5. Once the water is shut off this hose may then be attached to the line to be extended and the nozzle or other appliance re-applied to the hose line.

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6. If the line is to be extended on the ground or lower levels, the donut roll can be carried into the building. Two hose keys are still required.

NOTE: If, on paying out of the donut roll, the running bowline should become detached it may be re-applied and used to secure the hoseline if required.

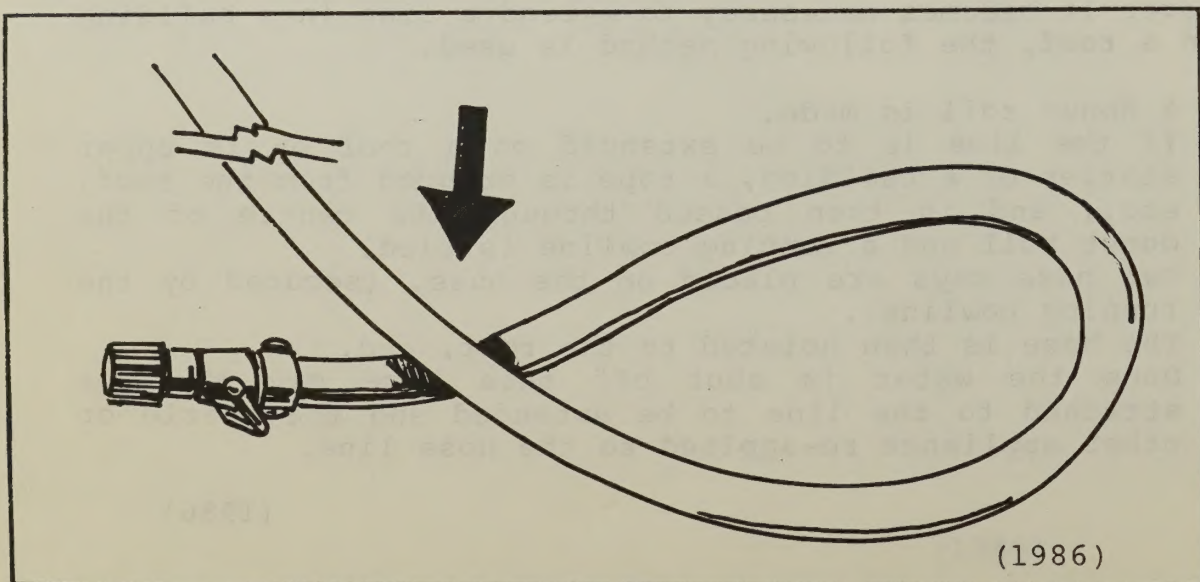
25. REPLACING BURST LENGTH (HOSE CLAMP)

The shut off must be made between the failure and the source of water supply, 1M behind the coupling of the damaged section. Two additional sections of fire hose should be secured from the apparatus for the replacement of one bad section. This practice is necessary because hoselines stretch to larger lengths when under pressure; thus, the couplings in line are invariably farther apart than the length of the replacement sections.

26. OPERATING HOSELINES (large hoselines)

a) One Firefighter Method

One firefighter can safely operate a larger hose line by forming a loop, passing the nozzle under the line, and sitting on the intersection.



b) Two Firefighter Method

The firefighter at the nozzle holds the nozzle with one hand and the hose, just back of the nozzle, with the other hand. Then rest the hoseline against the waist and across the hip. The back-up firefighter, in this case, must serve as an anchor, and this position is about 1M back. Here the back-up firefighter places the closest knee upon the hoseline. In this position, the back-up firefighter should be kneeling on one knee with both hands on the hoseline near the other knee.

NOTE: FOR ADDITIONAL INFORMATION, REFER TO I.F.S.T.A.
MANUAL

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CHAPTER 7

LADDERS

1. INTRODUCTION

Ladder Use

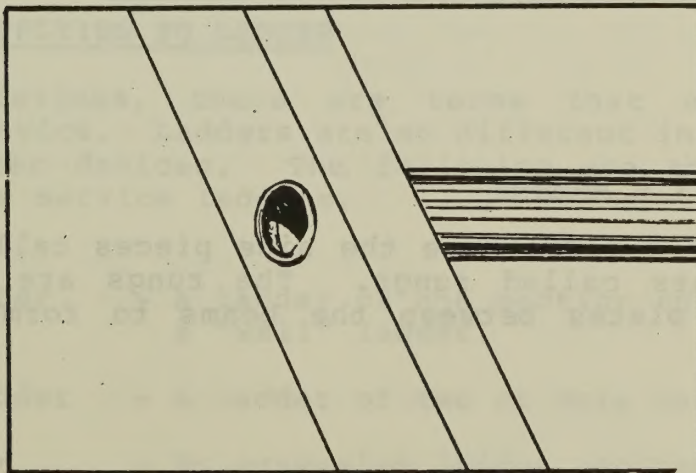
There are three primary uses for ladders in NORMAL fire service work:

- (a) Performing rescues when normal means of egress are rendered unusable by the fire.
- (b) To permit firefighters to climb to upper or lower portions of a structure.
- (c) To create a vantage point for actual firefighting.

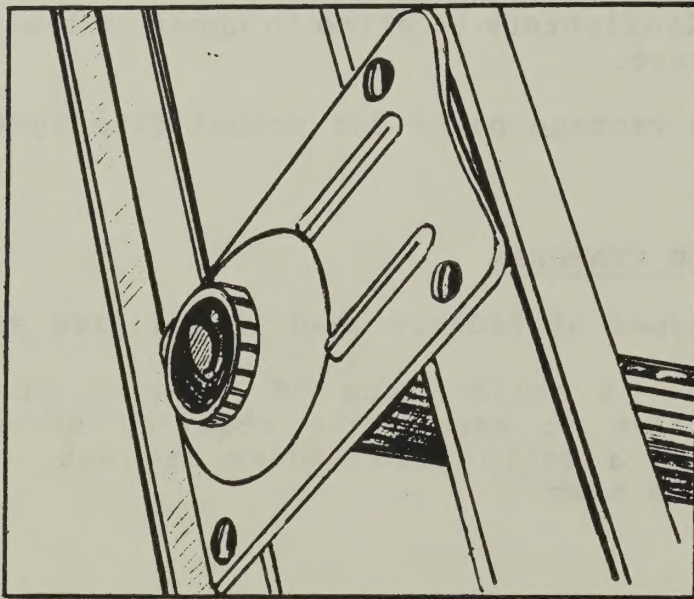
2. CONSTRUCTION FEATURES

There are two types of ladders used in the fire service:

- (a) Solid Beam - a solid piece of material of such shape and size to assure the required strength. The rungs of a solid beam ladder are set in the centre of the beam.



- (b) Trussed Beam - With solid beam ladders, the compression stress is on the top part and the tension stress on the bottom. The centre of the beams serve therefore only to hold the rungs. A part of the beam could be cut away without materially affecting the strength of the ladder. This is the principle upon which the trussed beam ladder is built. The rungs of a truss beam ladder are expanded into spacer plates to form a tight fit.



Principle Parts of a Ladder

The main parts of a ladder are the side pieces called beams and the cross bars called rungs. The rungs are expanded into the spacer plates between the beams to form a tight connection.

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Metals Used In Ladder Construction

1. Heat Treated Aluminum Alloy

- (a) Heat treated ALUMINUM ALLOY, which has the advantages of lightness, greater strength and less maintenance. Aluminum alloy hardening is a heat treatment taking place at approximately 500°C, but differs from steel tempering.

The hardening continues for about 4 days. This strength can be lost if the ladder is exposed to a temperature of 330°C at a fire, with no perceptible change in outward appearance. This constitutes a serious, hidden hazard in the aluminum alloy ladder. Aluminum alloy ladders are good conductors of electricity. "EXTREME CAUTION is necessary when working near electrical power sources".

2. Steel Alloy

STEEL ALLOY, which is the strongest of any known ladder construction, requires less maintenance but is much heavier and consequently, used for power operated aerials only.

3. TERMS APPLYING TO LADDER

With most devices, there are terms that apply to the particular device. Ladders are no different in this respect than are other devices. The following are the terms that apply to fire service ladders.

Straight Ladder - A ladder of one section only. Also called a "wall" ladder.

Extension Ladder - A ladder of two or more sections.

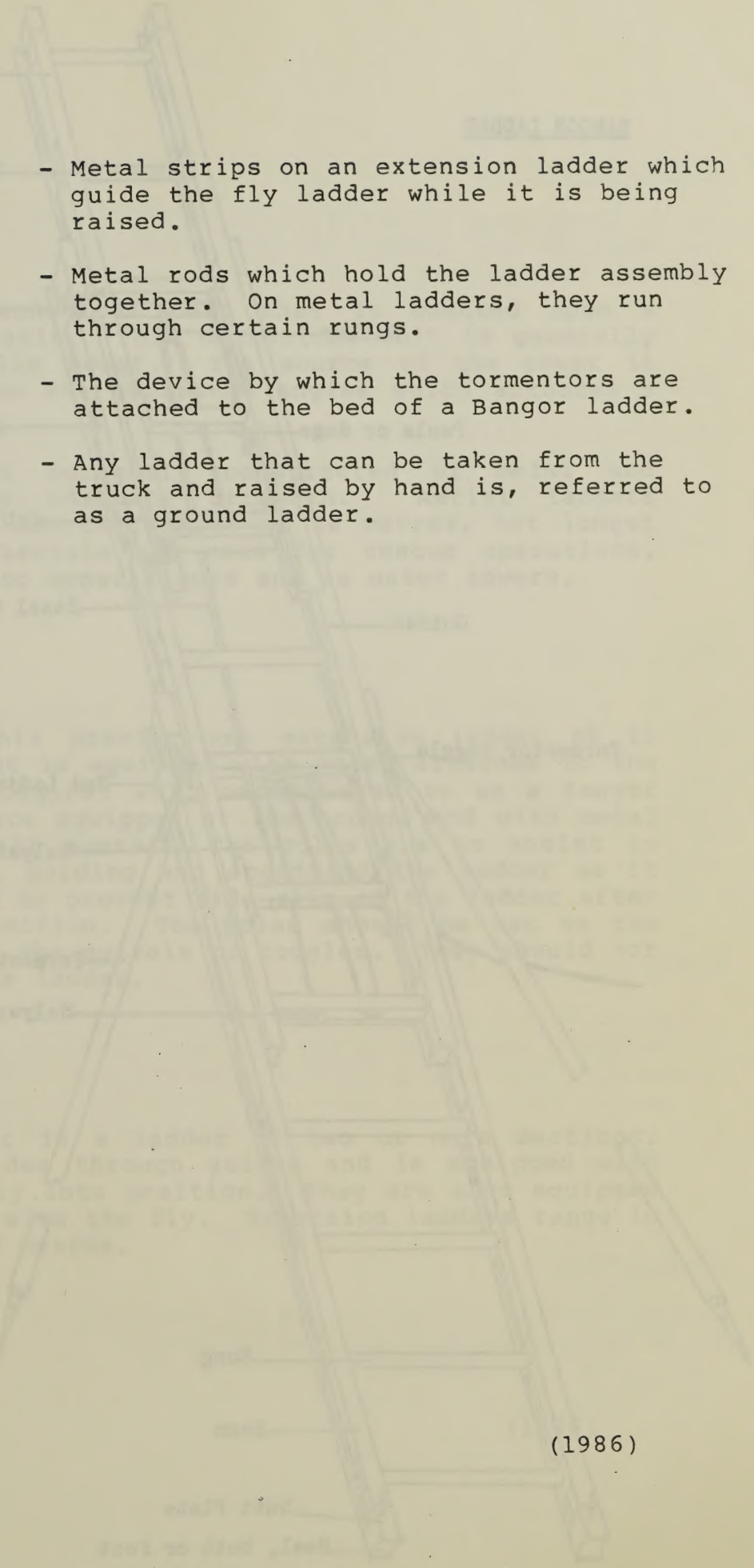
Bangor Ladder - An extension ladder equipped with poles for handling.

Main or Bed Ladder - The lower section of an extension ladder.

Fly Ladder or "Fly" - The upper section of an extension ladder
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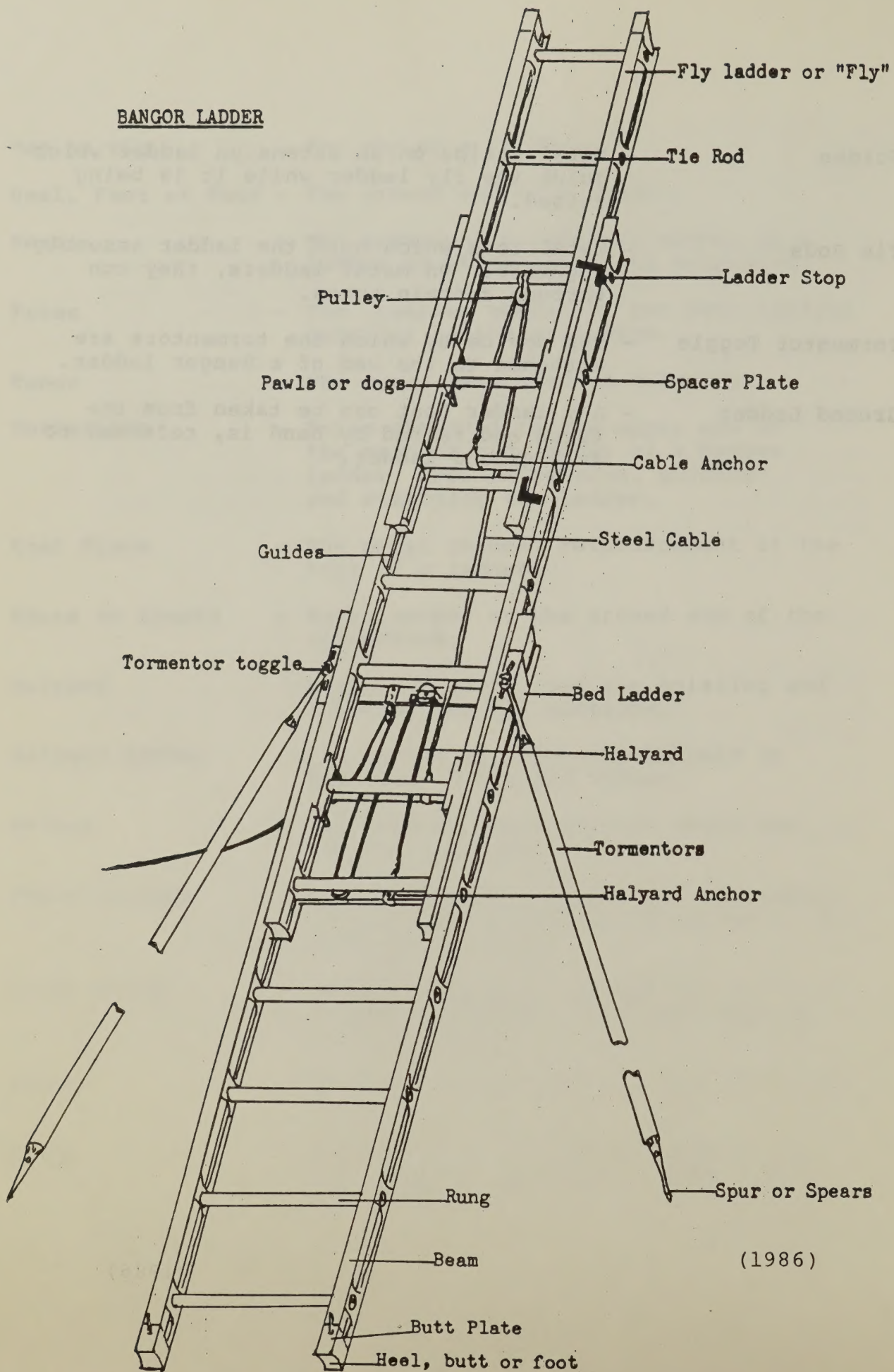
- Top or Tip** - The top of a ladder.
- Heel, Foot or Butt** - The ground end of a ladder.
- Beam** - The principal structural member of a ladder in which rungs are supported.
- Truss** - The tension member of the beam running parallel to the main beam.
- Rungs** - The cross bars used in climbing.
- Tormentors** - Poles attached to the upper end of the main or bed ladder of a Bangor ladder, used in raising, guiding and steadying the ladder.
- Heel Plate** - The metal channel reinforcement at the butt of a ladder.
- Spurs or Spears** - Metal spikes at the ground end of the tormentors.
- Halyard** - A rope or cable used for hoisting and lowering the fly sections.
- Halyard Anchor** - The device by which the halyard is fastened to the bed ladder.
- Pulley** - The grooved wheel through which the halyard is drawn.
- Pawls or Dogs** - The locks used; to lock the fly ladder into position after it is raised to the desired position.
- Truss Blocks** - Separation pieces between the rails of a trussed ladder. Sometimes used to support rungs.
- Braces** - Diagonal members between the rails and blocks.
- Stops** - Metal blocks or stops to prevent the fly ladder from being extended out of bed ladder.

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- Guides** - Metal strips on an extension ladder which guide the fly ladder while it is being raised.
- Tie Rods** - Metal rods which hold the ladder assembly together. On metal ladders, they run through certain rungs.
- Tormentor Toggle** - The device by which the tormentors are attached to the bed of a Bangor ladder.
- Ground Ladder** - Any ladder that can be taken from the truck and raised by hand is, referred to as a ground ladder.

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BANGOR LADDER



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4. TYPES OF LADDER

Aerial Ladders

An aerial is a mechanical unit that is mounted upon a specially built chassis. This mechanical unit is generally operated by hydraulic power. The source of the power is usually derived from the apparatus engine which actuates a hydraulic hoist.

Aerial ladders are currently constructed of metal and trussed to provide adequate strength. Aerial ladders generally range in length from 20 to 30 metres, but longer ladders are used. Aerials are used for rescue operations, getting hose lines to upper floors and as water towers.

Bangor Ladder

For purposes of this precis, any extension ladder of 11 metres and over that is equipped with poles attached to the main ladder with toggles, will be referred to as a Bangor ladder. The poles are equipped at the ground end with metal spikes which we call spurs. The poles are to assist in raising the ladder, guiding and steadying the ladder as it is being raised and to prevent side slip of the ladder after it is placed in position. The poles should be set on the ground in line with the swivels or toggles. They should not be forced behind the ladder.

Extension Ladder

An extension ladder is a ladder of two or more sections. The fly ladder slides through guides and is equipped with dogs to lock the fly into position. They are also equipped with a halyard to raise the fly. Extension ladders range in length from 4 to 19 metres.

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Straight Ladder

It is sometimes called a "Wall Ladder". It is a ladder of one section and ranges in length from 3 to 10 metres. The shorter ones may be of the roof ladder type.

Collapsible Ladder (Attic)

This ladder is especially useful for inside work. With the ordinary short ladder, difficulty is experienced in getting it around corners, in hallways and stairways. The 3 metre collapsible ladder eliminates this problem and is easily handled.

Roof Ladder

It is a ladder of one section with hooks set in moveable sockets at one end. The hooks are turned in when carried on the truck. These ladders range in length from 3 to 6 metres. They are used to enable fire fighters to reach the peaks of gabled roofs to facilitate removal of shingles, cut holes for ventilating and under emergency conditions can be used as a scaling ladder.

Elevating Platforms

Although elevating platforms are not generally considered to be ladders, some elevating platform apparatus carry ground ladders. This apparatus has some features which are similar to aerial ladders but they are primarily a portable elevator controlled by an operator. They are mentioned here to clarify their use.

Step Ladder

A short portable set of steps, supported by a hinged prop. It is primarily used for inside work.

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Combination Ladder (Combination Single/A - Frame Ladder)

Combination ladders are ladders that can be used both as a step ladder (A-Frame) or as a single ladder length (3.5m straight).

5. SELECTION OF THE PROPER LADDER

A good firefighter should be able to judge distance and select the length of ladder according to the height it is to reach. The height of floors, windows and roofs vary with different types of buildings. The following table can be used in most cases:

<u>Height of Building</u>	<u>Length of Ladder</u>
One storey roof	7 metre
Second storey window	7 metre
Two storey roof	10 metre
Third storey window	15 metre
Three storey roof	15 metre

6. LADDER DISTANCE FROM BUILDING

FORMULA - The formula used to determine the correct distance a ladder should be away from a building is:

DIVIDE THE USEABLE LADDER BY 4

plus cornice

EXAMPLE: 10m ladder, useable ladder length, 8m, 1m cornice

$8/4 = 2m + 1m = 3 \text{ metres}$ (butt of ladder should be placed this distance from the building to give the correct climbing angle).

(1986)

A practical way to check the distance is to stand at the base of the ladder on the bottom rung and rest your hands on the rung that is on a level with your shoulders. This will place your arm on a right angle to your body. If you can do this comfortably without bending your arms, the distance and climbing angle are correct.

7. LADDER LOADS

Fire service personnel should be alert to the maximum loading capacities for ladders. The load capacity is the total weight on the ladder including persons, their equipment, and any other weight such as charged hose lines.

It is considered good practice to allow 3 metres between load points.

The following table relates ladder size to ladder load:

<u>Size of Ladder</u>	<u>No. of Men</u>
Up to 6 metres	1 man
7 metre	2 men
10 metre	3 men
15 metre	4 men

8. LADDER CARRIES

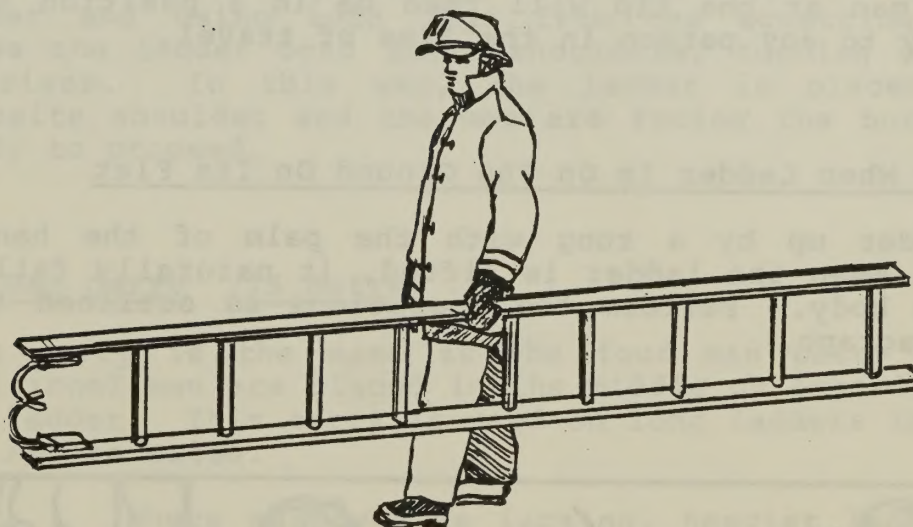
One Man Carry (Roof Ladder)

Remove the ladder from the apparatus and place on the ground on its beam. Judging the approximate centre balance point, face the butt of the ladder and pick up the ladder with the hand opposite to the shoulder upon which you intend to carry the ladder. Pivot on the foot closest to the ladder and swing the opposite arm through the ladder rungs in a position slightly to the rear of the centre balance point and grasp the rung at arms length (this will now place one rung at the front of the shoulder and one at arms length).

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The tip of the ladder should be lower than the butt of the ladder. All roof ladders must be carried with the hooks IN and with the tip FACING THE DIRECTION OF TRAVEL.

An optional method to the above carry is to judge the centre balance point and carry the ladder at arms length.



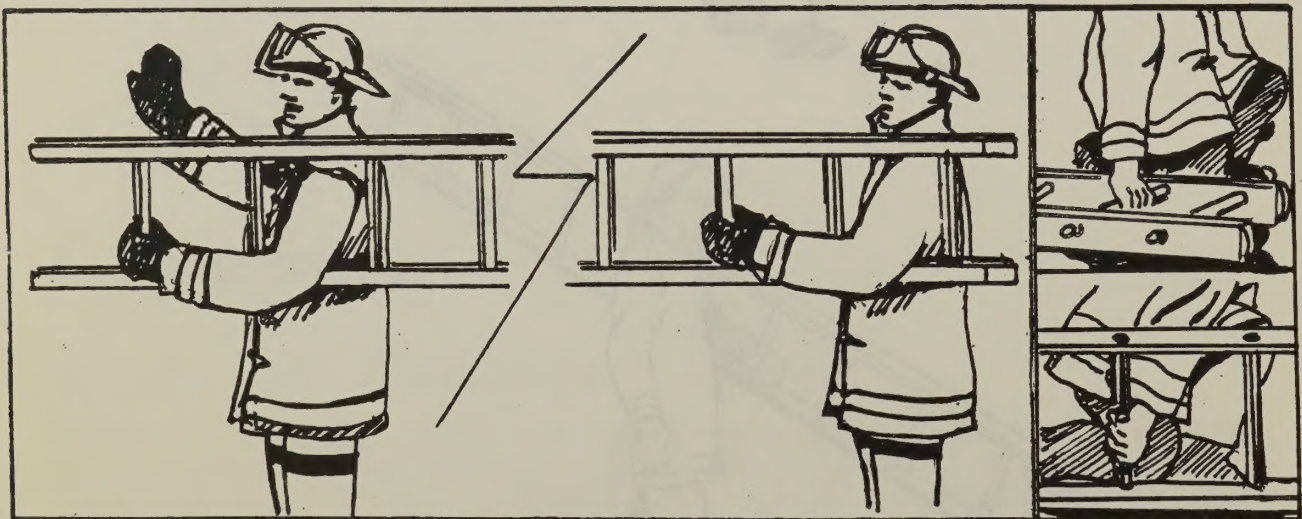
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Two Man Carry (Roof Ladder)

Two men remove the ladder from the apparatus and place it on the ground on the beam. With one man at each end of the ladder and on the same side, face the butt and pick up the ladder with the hand opposite to the shoulder on which the ladder is intended to be carried. Pivot on the foot closest to the ladder and swing your opposite arm through the ladder between the rungs and place the ladder on your shoulder. Both men now grasp the rung at arms length. This will now place a rung in the front of the shoulder and one at arms length. The man at the tip will then be in a position to prevent injury to any person in the line of travel.

Two Man Carry When Ladder Is On The Ground On Its Flat

Pick the ladder up by a rung with the palm of the hand turned down. When the ladder is lifted, it naturally falls alongside the body. Perform the operations as outlined in the above paragraph.



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Four Man Carry (10 metre)

1. Four men place the ladder on their shoulders, two at each end. The heel of the ladder should come off the apparatus first, and face toward the building where it is to be used.

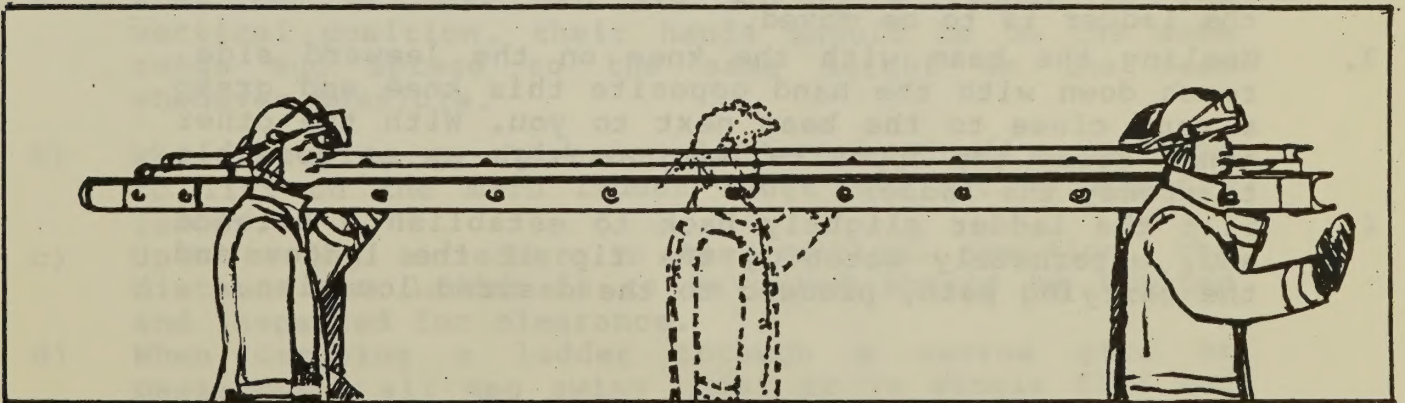
Four Man Carry When Ladder Is On The Ground

2. Four men take positions facing the tip of the ladder in the opposite direction in which they intend to go. Squatting down, they grasp a rung with the hand nearest the ladder and using both legs from the squatting position, raise the ladder onto their shoulders, turning under it as it rises. In this way, the ladder is placed upon the opposite shoulder and the men are facing the butt or heel, ready to proceed.

Six Man Carry (15 metre)

This carry is the same as the four man carry except two additional men are placed in the middle on opposite sides of the ladder. This carry is used on long ladders that require six men to raise.

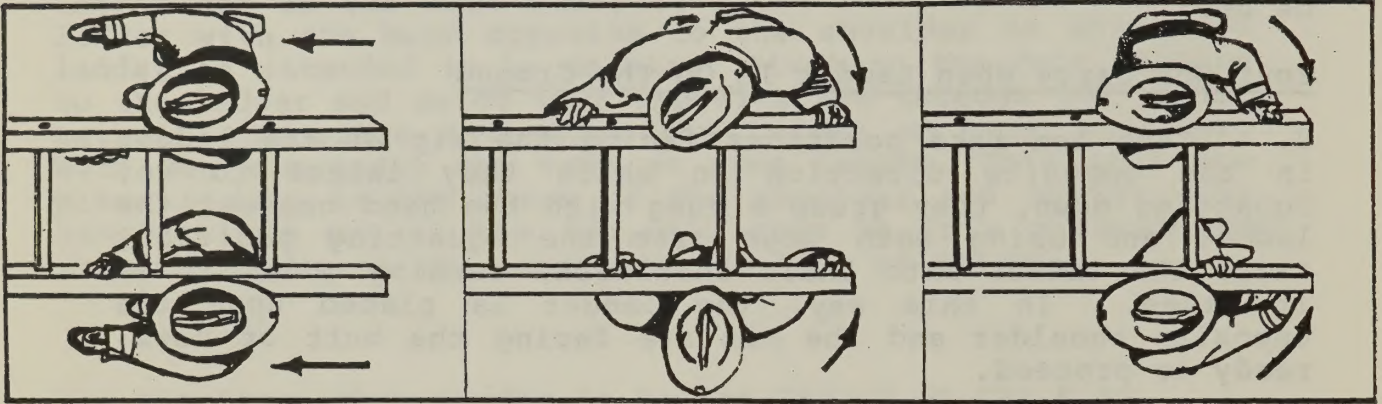
NOTE: Where manpower is lacking, heavier ladders may be carried by performing the two man ladder carry and positioning a third man in the middle near the centre of the ladder.



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Reversing Direction When Carrying A Ladder

Turn facing the ladder and at the same time, change the hands and complete the turn.



Ladder Carries - Vertical

If it is necessary to move a raised ladder (a ladder in the vertical position, if flys are not extended), it may be moved without lowering the ladder to the ground.

One Man Carry (short ladders)

1. Pull the ladder away from the building to an upright position.
2. Move to the side so that you are facing the direction the ladder is to be moved.
3. Heeling the beam with the knee on the leeward side, reach down with the hand opposite this knee and grasp a rung close to the beam next to you. With the other hand, grasp the opposite beam as high up as possible to steady the ladder.
4. Tilt the ladder slightly back to establish a balance and, alternately watching the tip of the ladder and the carrying path, proceed to the desired location.

(1986)

Two Man Carry (7 metre)

1. Pull the ladder to a vertical position - one man in front, one behind.
2. Each man takes a position at opposite beams.
3. Lift and balance the ladder in the vertical position and move to that desired location. One man stepping backward very carefully.

Four Man Carry (extension ladder (10 metre))

1. With two men under and two men in front, pull the ladder to a vertical position.
2. Lower the fly. The two men under do this.
3. With all men grasping a lower rung with the inside hand and high up on the beam with the outside hand, lift, steady, and carry the ladder to the desired position.

Six Man Carry (Bangor Ladder With Poles)

This carry is the same as the four man carry with the exception that an additional 2 men are employed as pole men. These two men take the poles out from the ladder and steady it with the other 4 men moving the ladder to the desired location.

General Information Concerning Ladder Carries

- a) When two or more men are moving a ladder in the vertical position, their hands should be on the same rungs and spread to the same height on the beam whenever possible.
- b) When carrying an extension ladder vertically, be sure to lift on the main ladder rungs and not on the fly ladder.
- c) Upon moving a ladder in the vertical position, the distance the ladder is to be moved should be limited and inspected for clearance.
- d) When carrying a ladder through a narrow gate or passageway, all men swing under it in single file and carry the ladder overhead at arms length. The men on the right side of the ladder move forward and those on the left side drop back. Hands should be spread wide on the rungs but kept off the beams.

(1986)

9. LADDER CLIMBING

Perfect rhythm is very essential in smooth ladder climbing. To secure the best possible rhythm, take every rung with the feet and every other rung with the hands; however, some ladder men prefer every rung with the feet and every rung with the hands. Never climb with your hands on the beam of the ladder unless you are carrying an object. Climb near the centre so as not to wobble the ladder and make the poles walk. Use the balls of the feet. Do not watch your feet while climbing and stay an arms length from the ladder. Never run up and down a ladder, climb steadily and smoothly.

Ladder Leg Lock

This is done by passing the foot, opposite the side you are to work, over the second or third rung above the one you are standing on, whichever is more comfortable. Pass the foot back through, locking the instep of the foot around the beam. Then slide the other foot along the rung to the opposite beam.



(1986)

Passing On A Ladder

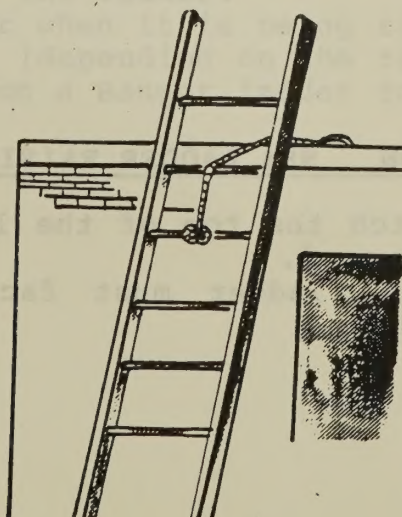
The procedure of passing on a ladder will be accomplished in the following manner:

1. The men must govern their rate of ascent and descent so that they will pass either above or below the centre point of the extended ladder.
2. The man descending will, on reaching the passing point, move to the extreme left side of the ladder and continue to climb down the ladder.
3. The man ascending will, on reaching the passing point, move to the extreme right side of the ladder and continue to climb up the ladder. The man ascending will also give sufficient notice to the man descending by an audible call "Passing".
4. Both men on passing will use their outside hand on the beam of the ladder and their inside hand on the rungs.
5. On completion of the pass, both men will move to the centre of the ladder with both hands on rungs, and continue to climb up or down.

Anchoring A Ladder With The Roger Rope Tool

To anchor a ladder in with a Roger Rope Tool the following procedure is to be followed:

Wrap the looped end of the rope around a rung. The hooked end is then passed through the loop and the knot is tightened on the rung. The hook can then be hooked onto a parapet wall or window sill, thus anchoring the ladder into the building. The slack must be taken from the rope in order to make it taut. This can be done by twisting the rope or by taking extra turns around the rung.



(1986)

10. PLACING LADDERS

1. Working In Windows With Hose Lines

It is always best to place a ladder in such a way that men can get in or out of the window easily. The ladder should be placed on the far side of the window or opposite the working side of the ladder. Two to three rungs inside the window.

2. For Ventilation

The ladder should be placed up wind; off to the side of the window, the reason for this being, should the window break or blow out, the man on the ladder, being off to one side, would be safe from injury two rungs above the top of the window.

3. To the Roof Of A Building

The ladder should be extended approximately four rungs over the edge of the roof.

4. For Rescue Work Using A Rope

The top of the ladder should be placed approximately four rungs above the top of the window and to the centre.

5. For Manual Rescue Work

The ladder should be placed in the centre of the window, with the top of the ladder level with the window sill.

11. GENERAL INFORMATION RE: LADDER RAISING

- a) All men should watch the top of the ladder when it is being raised or lowered.
- b) The fly on a metal ladder must face away from the building.

(1986)

- c) When raising a metal extension or bangor ladder at right angles, it must be first turned over on the ground so that the fly is facing down.
- d) When lowering a ladder into a building, it is the duty of the pole and beam men to guide the ladder to its desired location.

Spotting The Ladder

Place the ladder directly below the spot the top is desired to rest, the correct distance away from the building.

Duties of The Butt Man

- 1. To spot the ladder in the absence of an Officer.
- 2. To anchor the ladder to prevent it from swaying or moving.
- 3. Assist in raising of the ladder.
- 4. Release the poles on a bangor ladder from their bed.
- 5. Raise the flys (If two men are required, they should pull alternately hand over hand).

Butting The Ladder (Initial Raising Procedure)

Butt the ladder with the inside foot using the other foot as a brace. Reach out with the hands and assist in raising.

Duties Of The Beam Man

- 1. Raise and lower the ladder.
- 2. Guide the ladder when it is being raised or lowered.
- 3. Raise the flys. (depending on the raise).
- 4. Hand the poles on a Bangor ladder to the pole man.

(1986)

Raising The Ladder

Facing the tip of the ladder, reach down and grasp the ladder (1st or 2nd rung), with the inside hand and the knuckles facing forward. Raising the ladder overhead, swing under and using both hands alternately, raise the ladder to a vertical position.

Duties of Pole Men

1. Assist in guiding the ladder when it is being raised or lowered.
2. Help absorb some of the weight in the actual lowering and raising of the ladder.
3. Support the ladder from falling one way or the other when it is in the raised vertical position with the fly extended.
4. Assist in lowering ladder into the building.

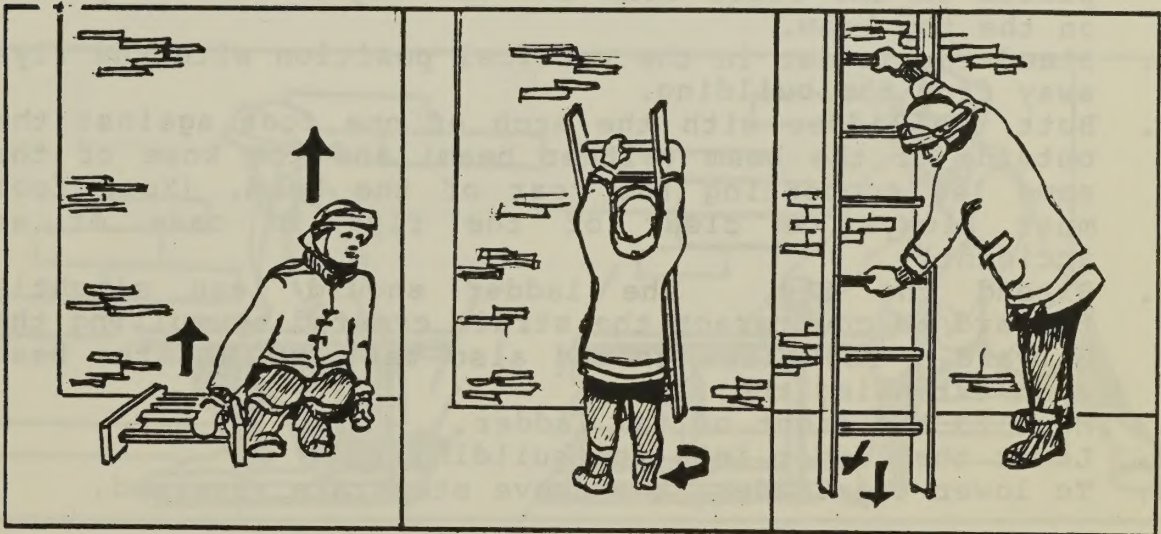
When lowering or raising the ladder, the pole men should be approximately 2 metres apart. It is very important that these men move in unison, work together and tell each other if the ladder starts to sway one way or the other. They should hold the spur of the pole between the fingers and not in the palm of the hand. They should also stand on the outside of the poles. Never walk backwards with a tormentor pole except when lowering the ladder.

(1986)

12. STANDARD LADDER RAISES

One Man Raise Straight Ladder

1. Carry the ladder to the desired location.
2. Place the butt of the ladder against the building or some secure object on the ground.
3. Using every other rung, raise the ladder in the prescribed manner with both hands, to a vertical position, by walking towards the foot of the ladder.
4. Grasp the ladder by the rungs with both hands, about three rungs apart, and set at a climbing angle.
5. To lower the ladder, the above steps are reversed.



(1986)

One Man Raise - 7 Metre Extension

(Shoulder Carry)

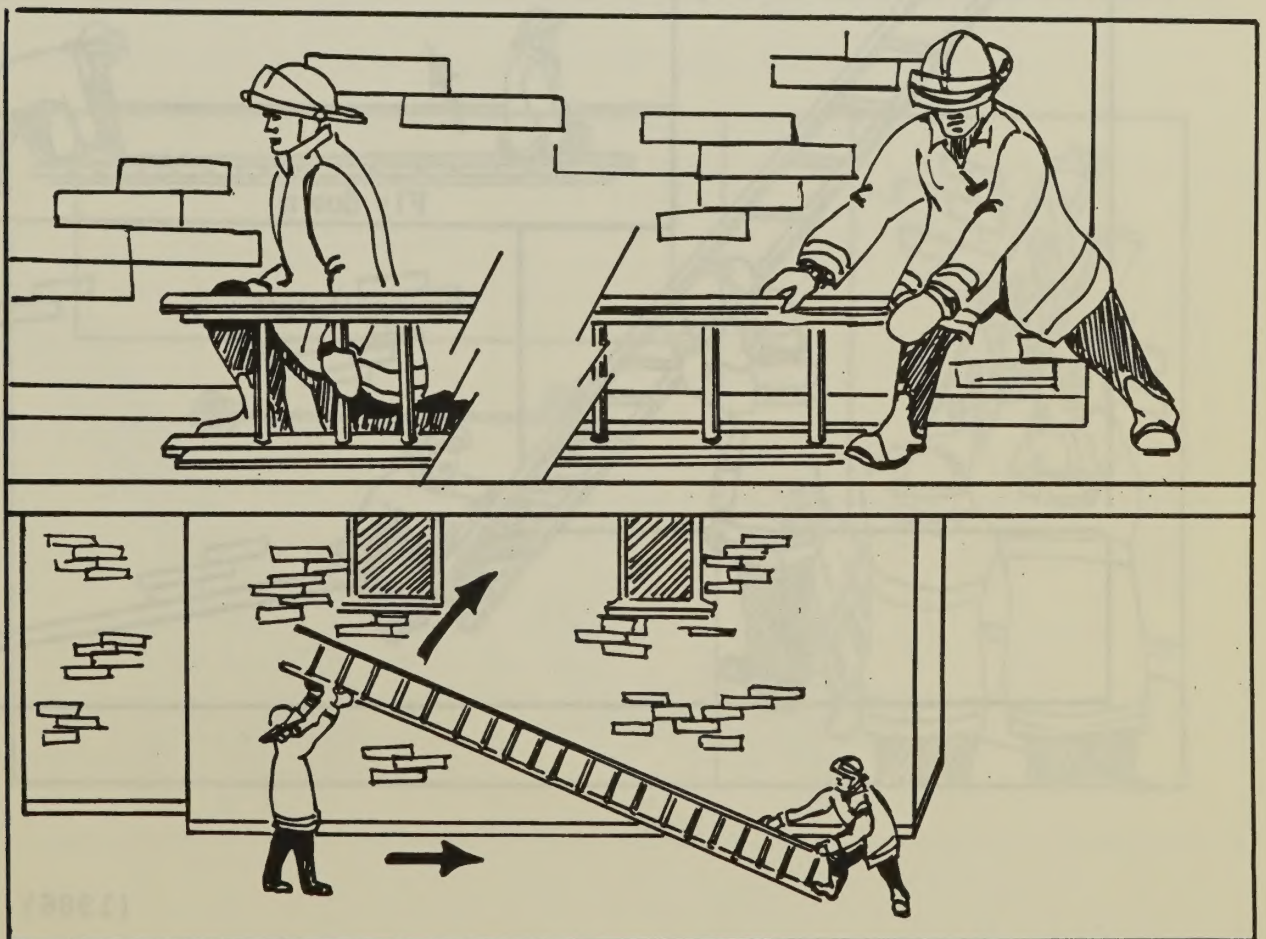
1. Remove the ladder from the apparatus and place on the ground.
2. Turn the ladder on its beam.
3. Proceed to tip of ladder and lift ladder and swing under and rest ladder on shoulder.
4. Work your way to the butt of the ladder until the ladder is balanced on your shoulder.
5. Spot the ladder where it is to be raised.
6. If carried on the right shoulder, the right hand is on the lower beam while the left hand is placed on the top beam.
7. If carried on the left shoulder, the left hand is placed on the lower beam and the right hand is placed on the top beam.
8. Stand the ladder in the vertical position with the flys away from the building.
9. Butt the ladder with the arch of one foot against the outside of the beam (either beam) and the knee of the same leg supporting the rear of the beam. (Your foot must always be clear of the flys in case of an accident).
10. Extend the fly. The ladder should lean slightly forward to counteract the strain created by pulling the halyard. The elbow should also rest against the beam when extending the fly.
11. Move to the front of the ladder.
12. Lower the ladder into the building.
13. To lower the ladder, the above steps are reversed.



(1986)

Two Man Raise (7 Metre Extension or Straight) Beam Raise
- Parallel

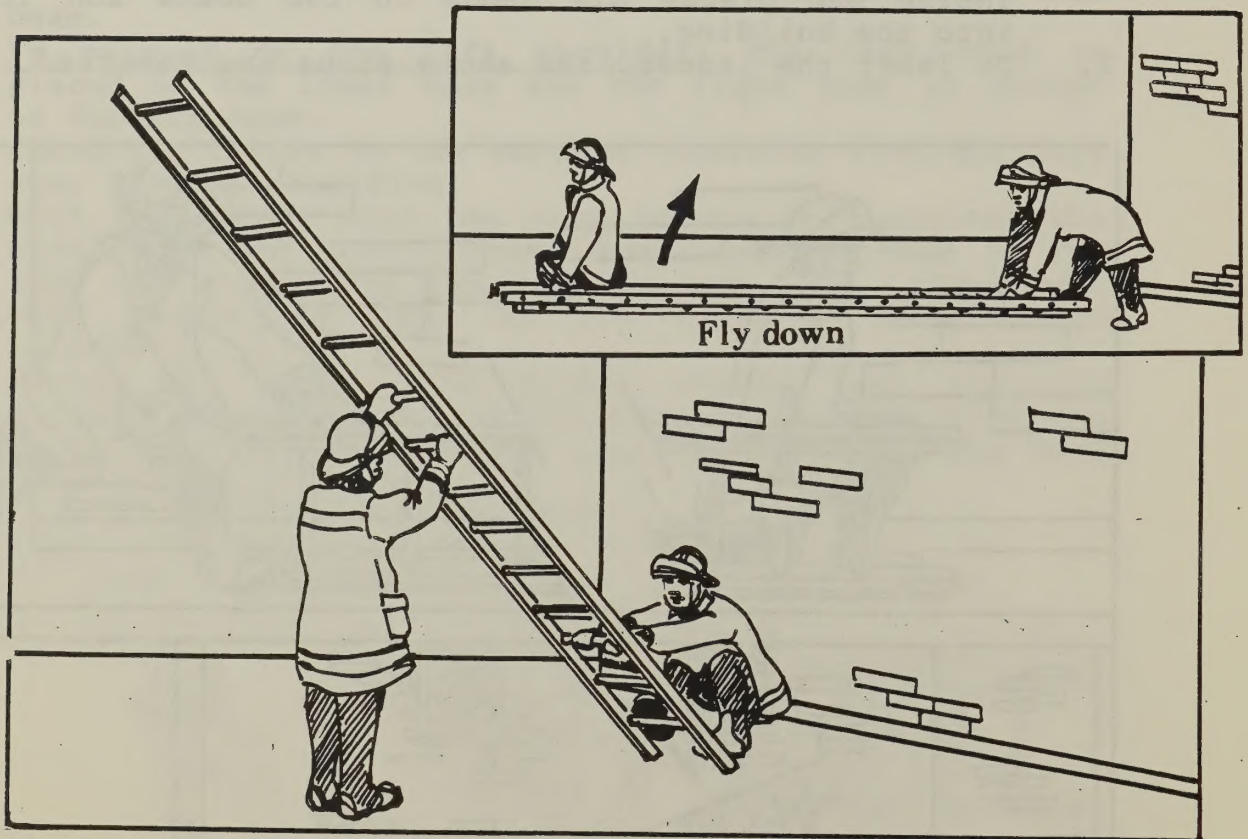
1. Butt man spots the ladder.
2. Roll ladder onto the outside beam.
3. Butt man butts the ladder on the bed ladder with the foot nearest to the building.
4. Beam man raises the ladder.
5. When ladder is vertical, the butt man stays at the rear and the beam man goes to the front.
6. The ladder is now butted by both men putting the arch of one foot against the outside of the one beam. (Both beams are now butted in a way that if the fly comes down, it would clear everyones feet).
7. The inside man extends the flys while the outside man supports the ladder with a hand on each beam.
8. When the flys are locked in, the beam man butts the ladder with one foot on the bottom rung while the inside man places his hands on the beams and lowers into the building.
9. To lower the ladder, the above steps are reversed.



(1986)

Two Man Raise (7 Metre Extension or Straight) Flat Raise - Right Angle

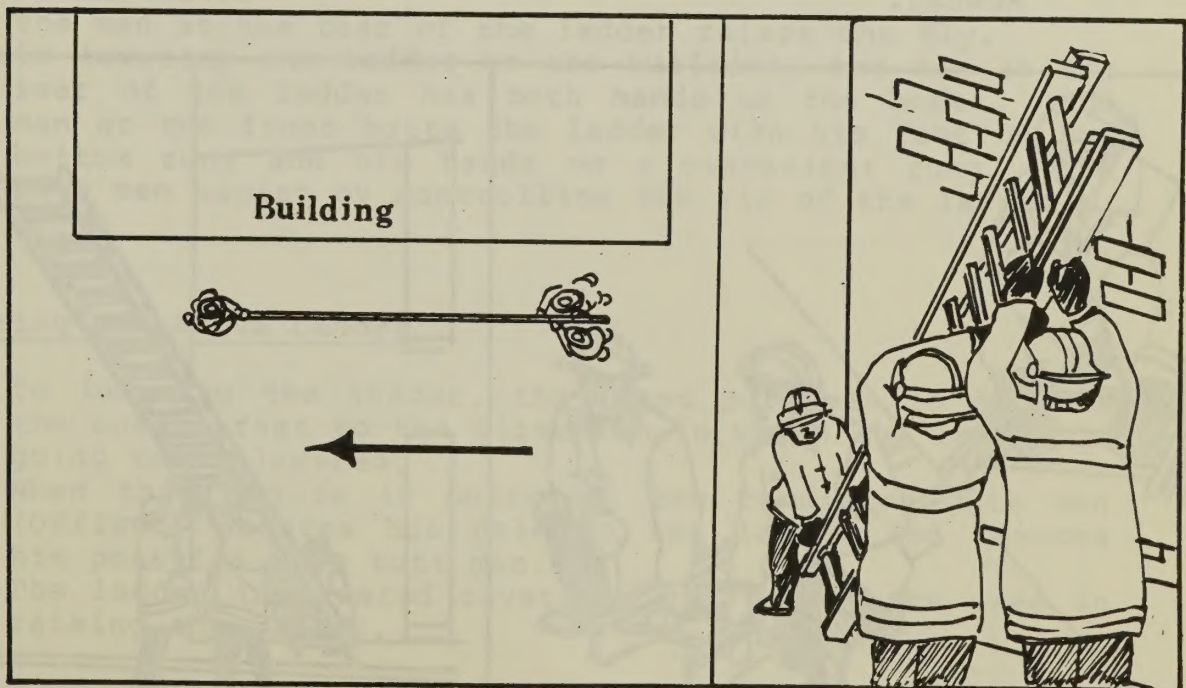
1. Position the ladder at right angles to the building with the butt in position for raising.
2. Roll the ladder over onto the flys.
3. The butt man butts the ladder on the lower rung while the beam man raises the ladder.
4. When the ladder is in the vertical position, use the same procedure as for a beam raise.
5. To lower the ladder, the above steps are reversed.



(1986)

Extension Ladder 10 metre (3 Men) Beam Raise Parallel To The Building

1. Spot the ladder parallel to the building.
2. Turn the ladder on the beam so that the flys face away from the building.
3. The butt man butts the ladder on the bed ladder with the foot nearest the building.
4. The 2 beam men pick the ladder up with the hand nearest the ladder, 1st or 2nd rung from the top and swing under the ladder.
5. Both men walk toward the butt raising the ladder hand over hand. The butt man can assist by pulling on the upper beam while the ladder is being raised.
6. When the ladder is in the vertical position, the butt man and 1 beam man will be at the rear and 1 beam man in front.
7. Now that the ladder is in the vertical position, the beam man at the rear of the ladder will raise the flys.
8. Lower the ladder into the building.
9. To lower the ladder, the above procedures are reversed.

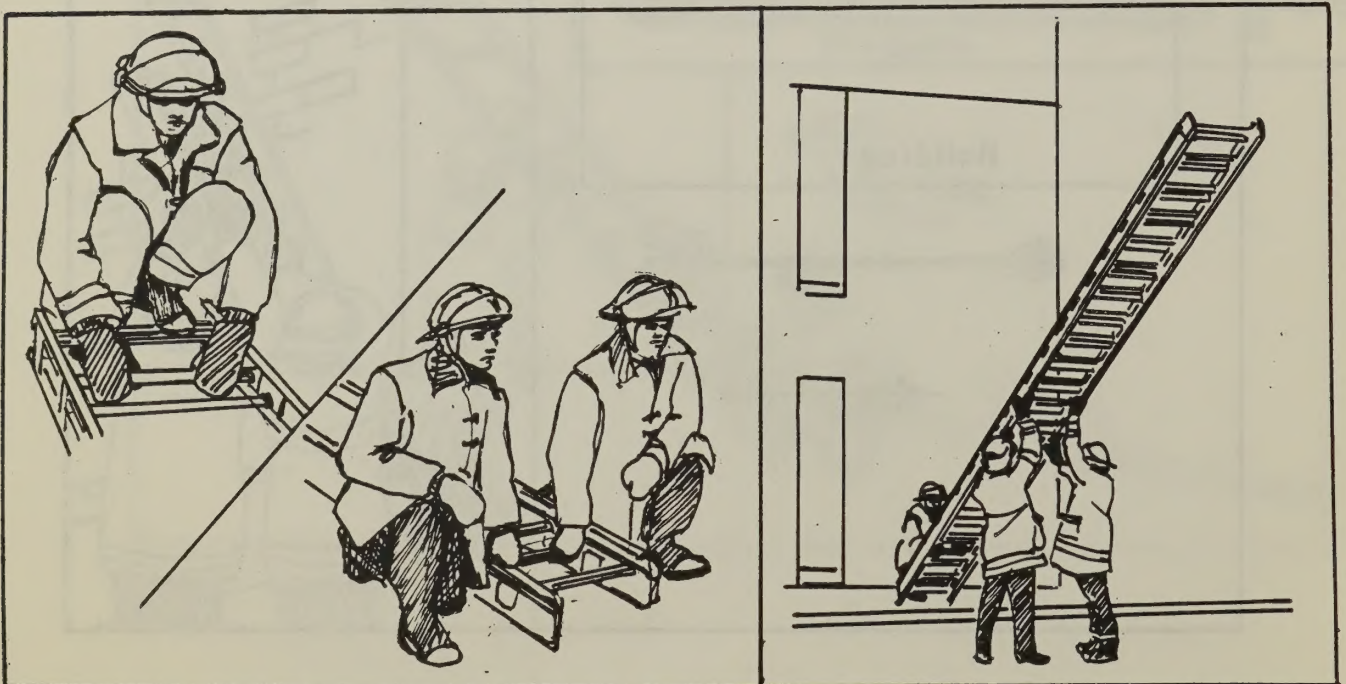


(1986)

Extension Ladder 10 Metre (3 Men) Flat Raise Right Angle to Building

1. Place ladder on its flat at right angle to the building.
2. Roll the ladder over onto the flys.
3. The ladder is in a position to be raised with one man at the butt and 2 beam men at the tip.
4. The 2 beam men pick the ladder up with the hand nearest the ladder, one or two rungs from the top, and swing under the ladder.
5. Both men walk towards the butt raising the ladder hand over hand. The butt man can assist by pulling on the rungs while the ladder is being raised.
6. When the ladder is in the vertical position, the butt man and one beam man will take up a position at the rear and one beam man in front of the ladder.
7. Now that the ladder is in the vertical position, the butt man at the rear of the ladder will raise the fly.
8. Lower the ladder into the building.
9. To lower the ladder, the above procedures are reversed.

Note: When the flys are MOVING, you butt the ladder on the BEAM.
When the flys are NOT MOVING, you butt it on the RUNGS..



(1986)

Bangor Ladder Raises (4 & 6 Men)

Beam Raise 15 Metre Parallel to the Building (4 Men)

In this evolution, the Officer will be the inside butt man.

1. Spot the ladder on its flat parallel to the building.
2. The outside butt man passes the outside pole to the outside pole man who is in position to accept the pole.
3. The outside butt man takes a position at the tip of the ladder with the beam man.
4. The ladder is turned on its outside beam.
5. The butt man (officer) butts the ladder with the foot that is closest to the building on the bed ladder.
6. The ladder is raised to the vertical position.
7. The butt man (officer) takes the remaining pole off the ladder and takes a position at the front of the ladder.
8. When the ladder is stabilized, the other pole man comes to the front of the ladder. Both pole men should be approximately two metres apart.
9. One beam man is at the front of the ladder and one is at the rear.
10. The man at the rear of the ladder raises the fly.
11. In lowering the ladder to the building, the man at the rear of the ladder has both hands on the beams. The man at the front butts the ladder with his foot on the bottom rung and his hands on a convenient rung. The pole men assist by controlling the tip of the ladder.

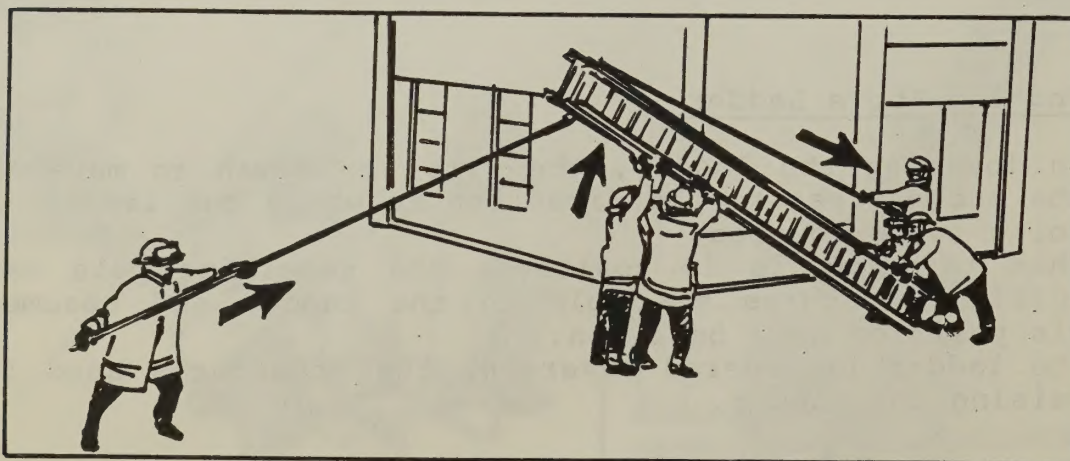
Lowering the Above Ladder

1. In lowering the ladder, the first pole man to move is the one nearest to the direction in which the ladder is going to be lowered.
2. When this man is in position, the remaining pole man (Officer) secures his pole to the ladder and resumes his position as a butt man.
3. The ladder is lowered reversing the procedures used in raising the ladder.

(1986)

Beam Raise 15 Metre Parallel to the Building (6 men)

1. Spot the ladder.
2. Each man takes his position. The beam men, butt men and the outside pole man take their regular positions. The inside pole man takes a position on the inside of the ladder near the butt.
3. Extend the outside pole to the outside pole man.
4. Turn the ladder on its beam, flies away from the building.
5. The butt man hands the inside pole to the inside pole man. The poles should be kept approximately 10° off the ladder to prevent them from binding.
6. Raise the ladder. The outside pole man pushes and the inside pole man pulls when in line with the ladder.
7. When the ladder is in the vertical position, the poles are then brought around in front of the ladder.
8. Extend and lock the fly.
9. Lower the ladder into the building.
10. In lowering the ladder the procedure is reversed. The inside pole man must remember to step out of line with the ladder when he starts to interfere with the butt positions (i.e. ladder is almost lowered to the ground).

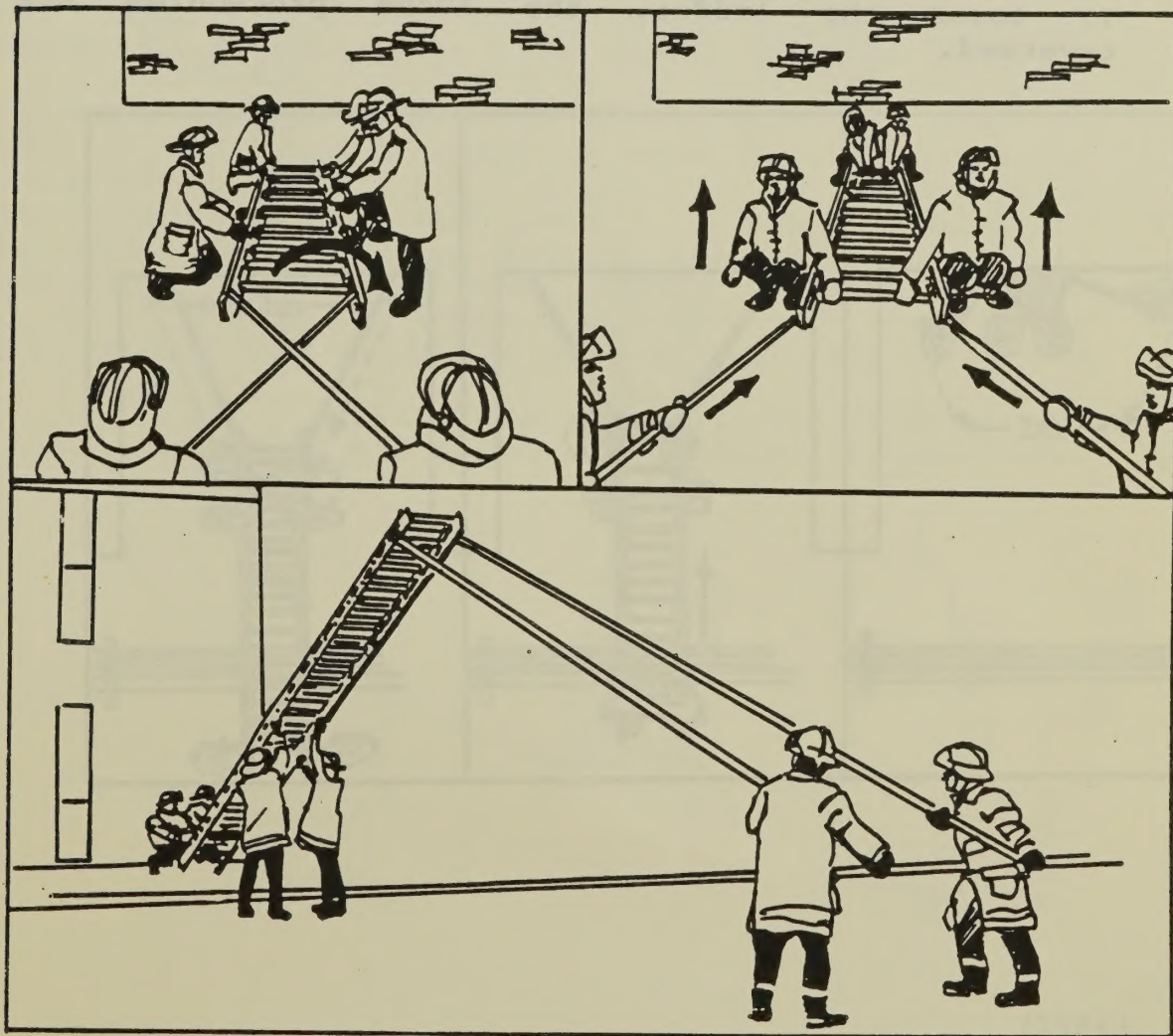


(1986)

Flat Raise 15 Metre Right Angle to the Building

(6 Men)

1. Spot the ladder.
2. Each man takes his position, the beam men pass the poles over to the pole men.
3. Turn the ladder over on the fly. To do this we cross the poles and turn the ladder in the direction that the top pole is facing.
4. The beam men grasp the bed ladder with the inside hand 1 or 2 rungs from the tip and swing under and raise the ladder. (Pole men take the weight from the beam men as soon as possible, pushing the ladder to a vertical position.)
5. The fly is extended and the ladder is lowered into the building.
6. When the butt or climbing angle is set, the poles are placed at right angle to the toggles.
7. To lower the ladder, the procedure is reversed.



13. Emergency Ladder Raises

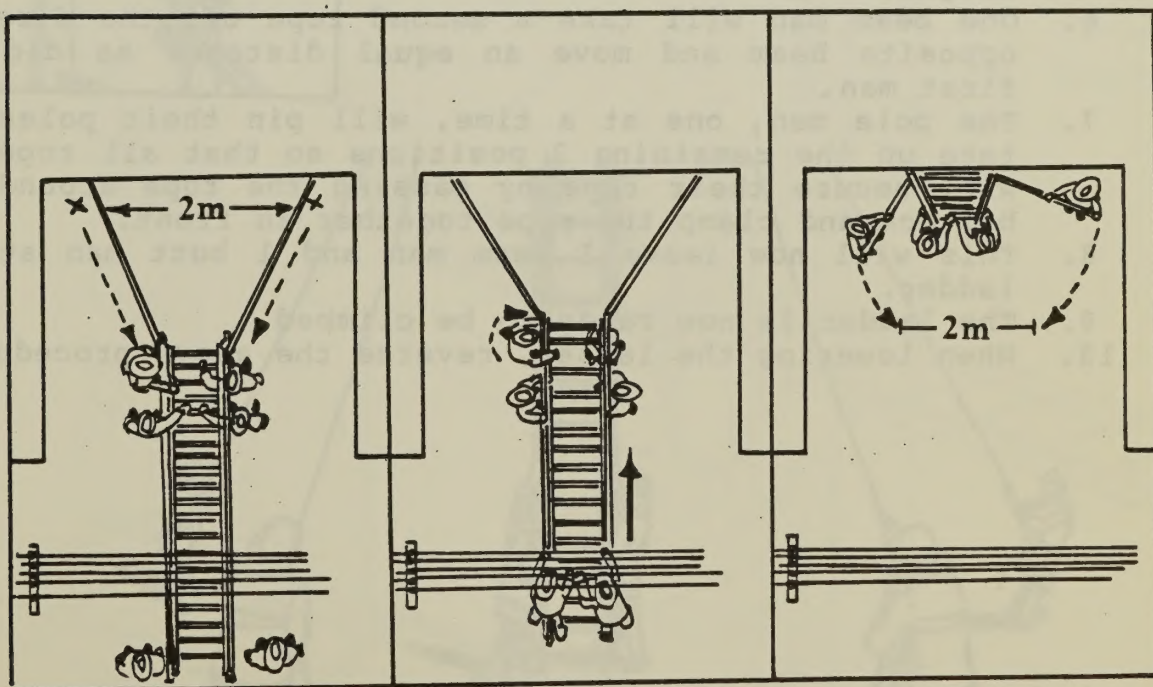
Under Wire Raise

1. Spot the ladder at right angle to the building with the fly up and the tip towards the building.
2. Extend the poles. Beam men hand the poles to the pole men who place them against the building approximately 2 metres apart.
3. The pole men and beam men lift the ladder, swing under and shove the ladder up, hand over hand.
4. The butt men, keeping the butt on the ground, push the ladder towards the building till the approximate butt position has been reached.
5. The pole men take the poles and push the ladder to a vertical position.
6. The pole men move the poles to the front and the 2 men at the rear of the ladder extend the fly.
7. Lower the ladder into the building.
8. When the climbing angle is set, the poles are set at right angle to the toggles.
9. To lower the ladder, the above procedures are reversed.



NOTE: If there is a shortage of manpower, the above raise may be done with 4 men.

1. The beam men place the poles against the building.
2. With 2 beam men lifting the ladder and 2 butt men pushing the butt towards the building, the ladder is raised to the approximate butt position.
3. The two beam men move out and become pole men and one butt man moves to the rear of the ladder to act as a beam man.
4. The pole men push the ladder to the vertical position, then move the poles to the front.
5. The man at the rear of the ladder extends the fly.
6. Lower the ladder into the building and set the poles.
7. To lower ladder, reverse the above procedures.



(1986)

14. HOISTING LADDERS

Ladders are sometimes needed on roofs or upper floors of buildings. Hoisting with a rope is probably the easiest and quickest way to accomplish this task.

Step 1: Tie a large bowline knot and place the loop from the underneath side between the rungs of the ladder about one-third the length of the ladder from one end.

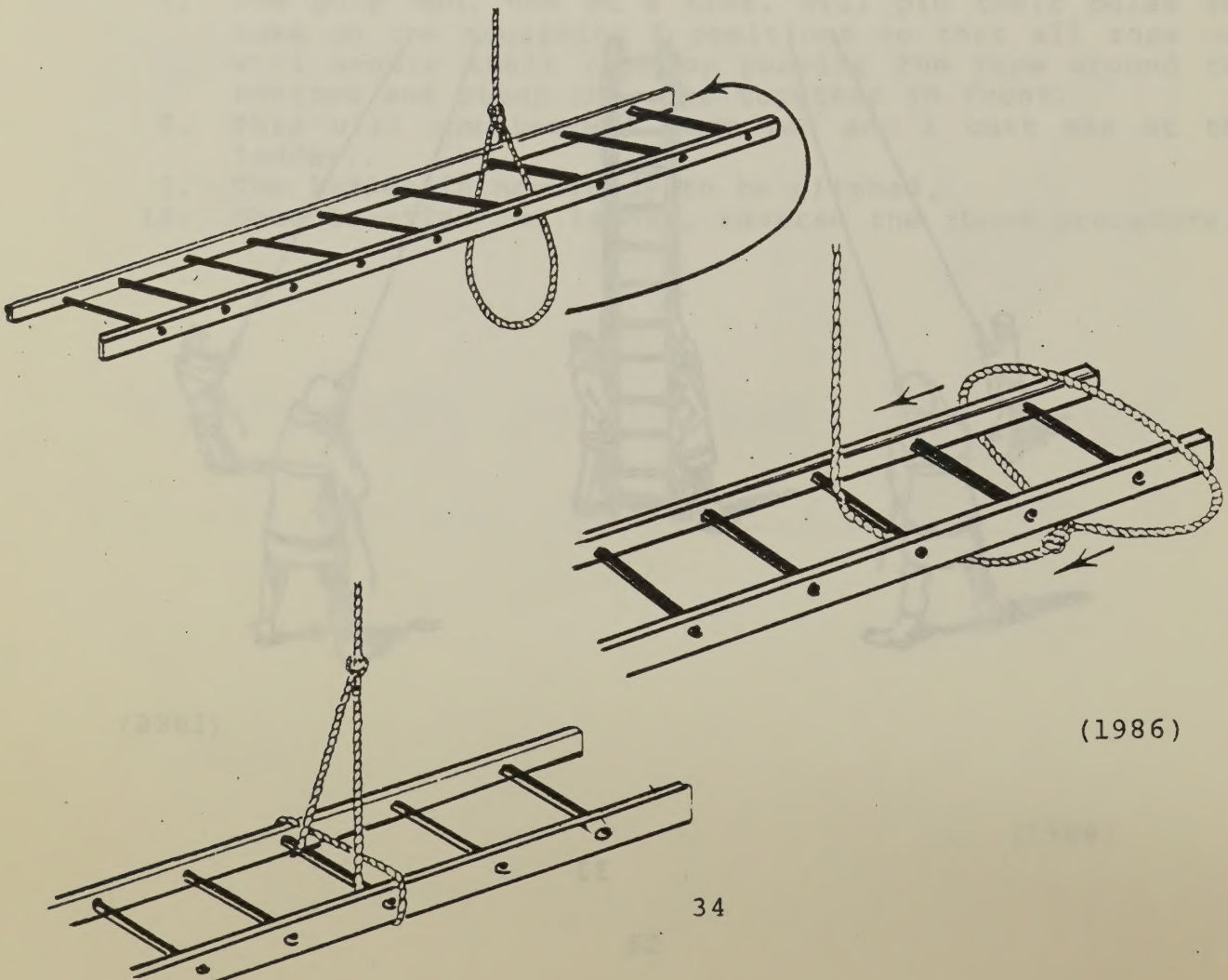
Step 2: Pull the loop and knot to the end of the ladder and place the loop over the beam ends.

Step 3: Complete the tie by pulling on the standing part of the rope.

Step 4: Firefighters in the building take up the slack line. The firefighters on the ground assist in lifting the ladder to vertical.

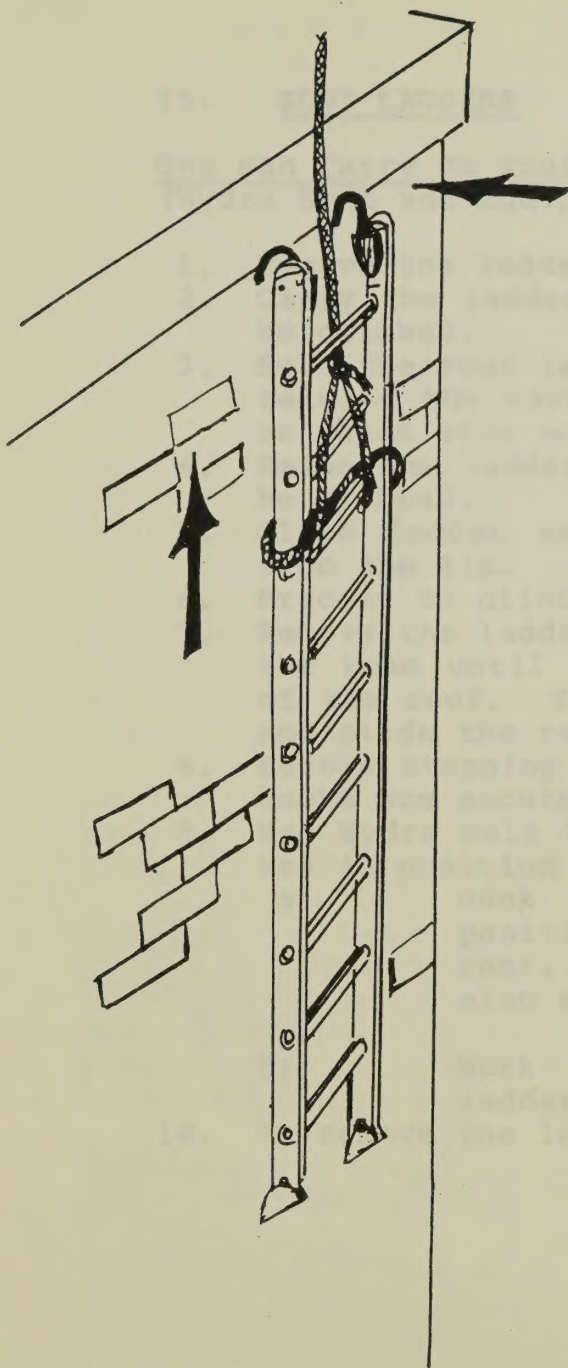
Step 5: The ladder is then hoisted up the outside of the building.

NOTE: When raising - rope is on the inside.
When lowering - rope is on the outside.

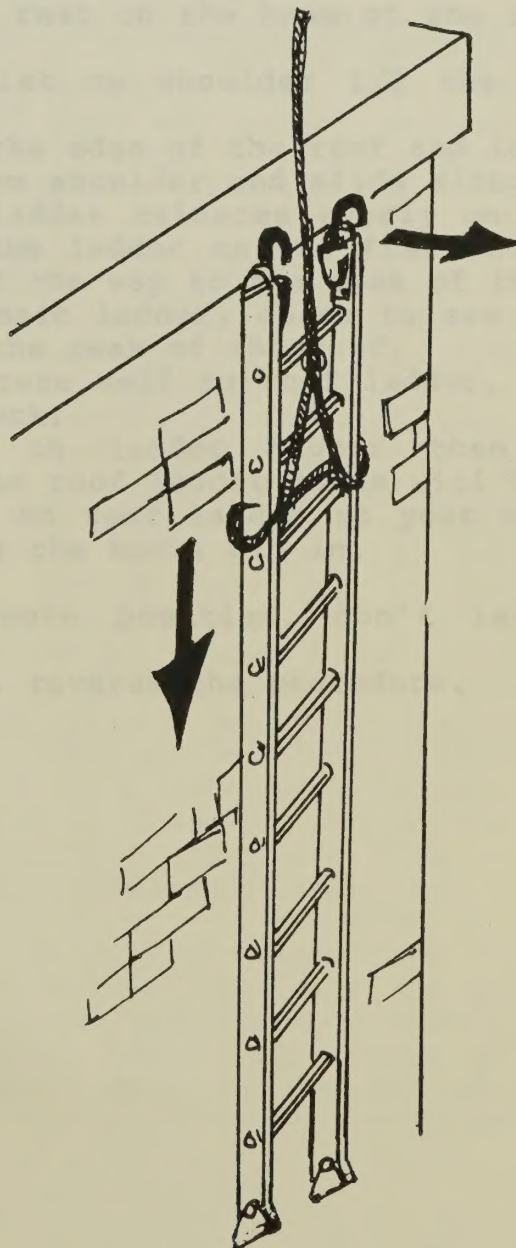


(1986)

Raising and Lowering a Roof Ladder using a Rope



"HOOKS IN"
when
RAISING



"HOOKS OUT"
when
LOWERING

(1986)

1. General description

The model is a representation of a building structure, showing the main components and their arrangement. It is designed to illustrate the structural system and the load transfer path.

Step 1: The model is divided into two main parts: the structural frame and the non-structural components. The structural frame is the primary load-carrying system, while the non-structural components are secondary elements that do not carry the main load.

Step 2: The structural frame is further divided into the columns and the beams. The columns are the vertical load-carrying members, and the beams are the horizontal load-carrying members.

Step 3: The non-structural components are divided into the walls and the floors. The walls are the vertical non-structural elements, and the floors are the horizontal non-structural elements.

Step 4: The model is then analyzed to determine the load transfer path. This involves identifying the primary load-carrying members and the secondary load-carrying members.

Step 5: The model is then used to illustrate the structural system and the load transfer path. This involves showing the main components and their arrangement.

Diagram showing the structural frame and the non-structural components.



15. ROOF LADDERS

One Man Carry To Roof Of Building

(Wydra Belt and Equipment Required. Example = Axe)

1. Remove the ladder from apparatus or off the ground.
2. Carry the ladder to the butt of the ladder which is to be climbed.
3. Butt the roof ladder against the beam of the ladder and release the hooks. (Butt the ladder against the beam on which side work is to be done).
4. Raise the ladder and rest on the beam of the ladder to be climbed.
5. Climb ladder and hoist on shoulder 1/3 the distance from the tip.
6. Proceed to climb to the edge of the roof and lock in.
7. Remove the ladder from shoulder and slide along roof on the beam until the ladder balances evenly on the edge of the roof. Turn the ladder on the flat, hooks DOWN and slide the rest of the way to the peak of the roof.
8. Before stepping off main ladder, check to see that the hooks are secure on the peak of the roof.
9. Use Wydra Belt to secure self to roof ladder, when you are in position to work.
 - a) Hook belt on ladder higher than working position, so roof ladder hooks will bite into roof. Stay on roof ladder so your weight is also making the hooks dig in.
 - b) Work in above position, don't leave roof ladder.
10. To remove the ladder, reverse the procedure.

(1986)

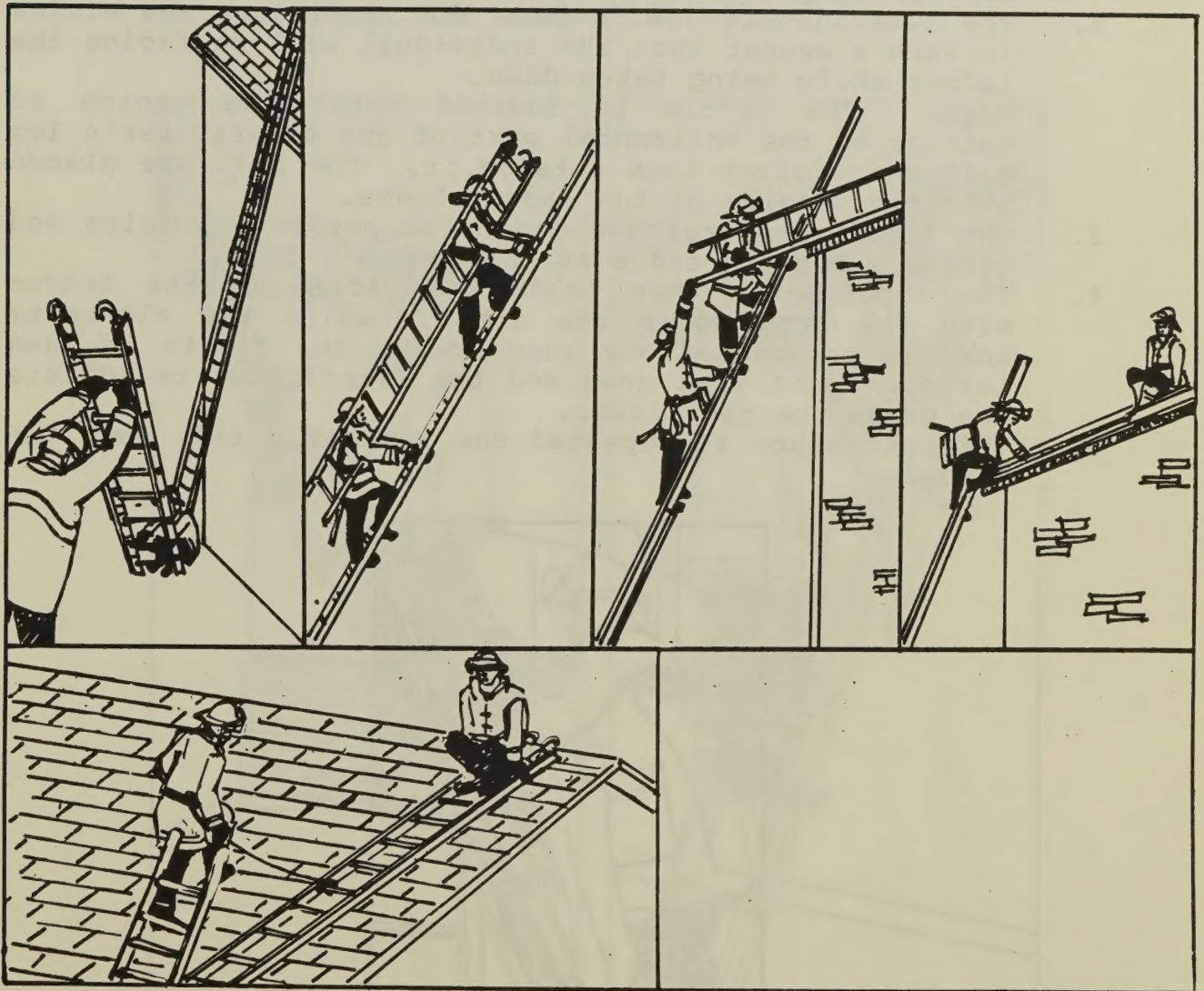
Two Man Carry To Roof Of Building

(2 Wydra Belts and Equipment Required. Example = Axe)

1. Remove the ladder from the apparatus or off the ground.
2. Carry the ladder to the ladder which is to be climbed and place roof ladder at right angles to the beam on the side the work is to be done.
3. Top man releases hooks and raises the ladder while other man butts.
4. One man climbs ladder and grasps roof ladder 3rd rung from the tip and places it on his shoulder. He proceeds to climb till the roof ladder is off the ground and then he stops.
5. The second man puts the ladder on his shoulder 3 rungs from the bottom.
6. Both men climb together so the weight is distributed evenly, taking the pace from the bottom man. (hands on rungs).
7. When the top man reaches the edge of the roof he locks in.
8. The bottom man continues to climb while top man is guiding the ladder onto the roof until the centre balance point has been reached.
9. When the bottom man can no longer assist top man, he removes the ladder from his shoulder and the top man continues to slide the ladder to the peak of the roof in the prescribed manner.
10. Before stepping off the main ladder, check to see that the hooks are secure on the peak of the roof.
11. Top man proceeds to a position 1 or 2 rungs from the top of the roof ladder and locks on with his wydra belt. His duties are to make sure the roof ladder hooks stay secure in the peak by keeping his weight on the roof ladder.
Note: If the bottom man (worker) has to position himself low on the roof ladder the top man will move down an additional 1 or 2 rungs.
12. Bottom man proceeds to desired work position and locks on with his wydra belt to roof ladder (secure the belt a few rungs higher so roof ladder hooks will bite into the roof.)
13. If changing positions on the roof ladder one man will unlock his belt and move. The other man will stay locked in until the first man has completed his move.
14. To remove the ladder both men lock in on main ladder (bottom man positions himself 3 or 4 rungs from the top man.)

(1986)

15. The top man clears the hooks, turns the ladder on the beam and slides the ladder down off the roof to the bottom man who places the ladder on his shoulder in the proper position. He then unlocks and starts to descend the ladder.
16. The top man continues to guide the ladder till a position is reached (bottom man stops) where he can hoist the ladder on his shoulders.
17. The top man then unlocks and both men descend together taking the step from the bottom man.



(1986)

16. LADDER RESCUE OPERATIONS

Bringing Unconscious Persons Down Ground Ladders

Technique #1 (Place ladder at centre of window level with sill)

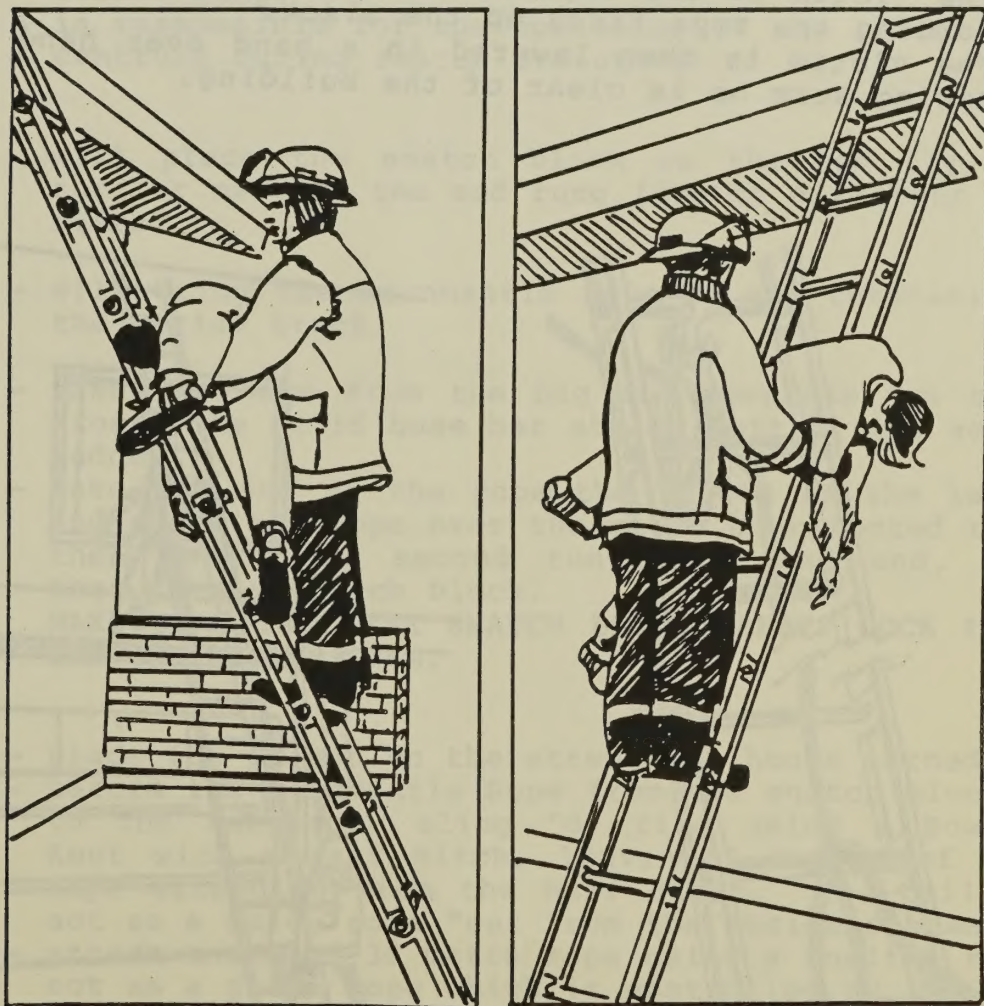
1. A firefighter climbs to near the top of the ladder. One foot is placed on a rung in such a way that the knee is bent 90 degrees and the upper leg is in a horizontal plane.
2. The firefighters inside pass the victim out the window in such a manner that the individual will be facing the ladder while being taken down.
Note: The victim is lowered until the crotch is resting on the horizontal part of the firefighter's leg with the victims legs outside it. The feet are placed over the outside of the ladder beams.
3. The firefighter reaches under the person's armpits and grasps a rung in front of the person's face.
4. The firefighter then holds the victim to the ladder with the arms under the armpits while the alternate knee is positioned one rung lower. The victim is then let down onto that knee and the firefighter re-adjusts the grasp one rung lower.
5. This procedure is repeated one rung at a time down the ladder.



(1986)

Technique #2 (Place ladder at centre of window, level with sill)

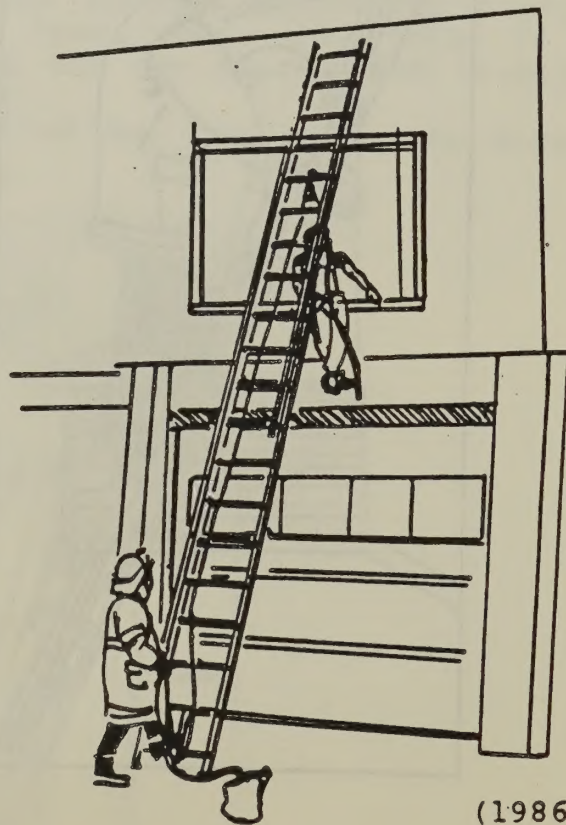
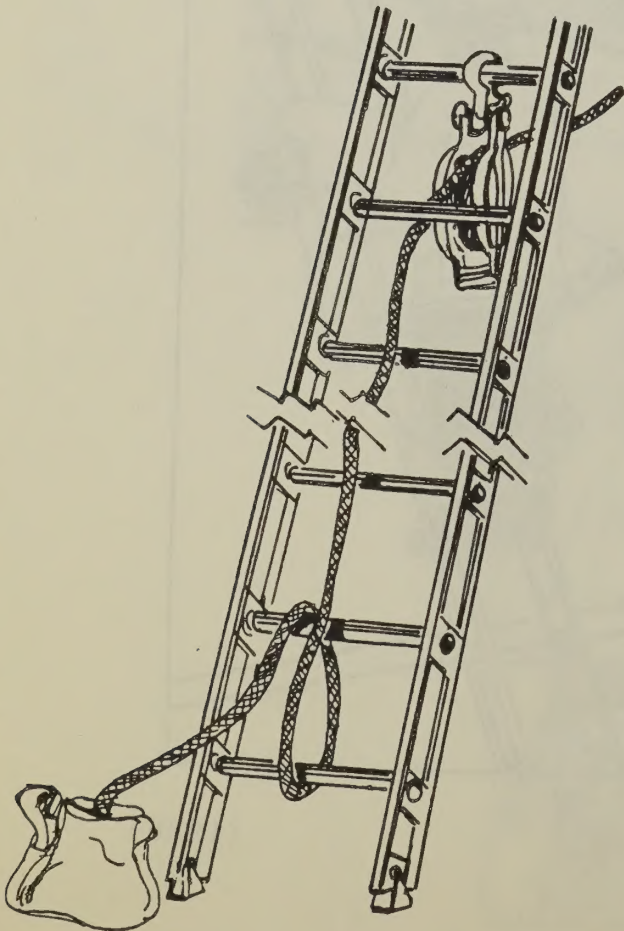
1. Victim is lifted out to the rescuer on the ladder, laying the victim across the ladder facing the building.
2. The victim is supported at the crotch by one of the rescuer's arms and at the chest by the other arm.
3. The firefighter's hands grasp the beams and slide down as he descends.
4. The firefighter can easily stop to rest by pinning the victim between the ladder and himself.



(1986)

Technique #3 - Rope Rescue from a ground ladder
(Place ladder 4 rungs above top of window and to the centre)

1. Using the Kermantle Rescue rope, wrap the rope around the bottom two rungs and advance the rope up the outside of the ladder (Follow Illustration Below).
2. While advancing the rope, also take a snatch block and place it on the rung in line with the middle of the window. (make sure snatch block is locked in and facing forward toward the window).
3. Bring the rope under the rung below the snatch block, through the snatch block and into the window (Follow Illustration Below).
4. Tying the rescue knot to the victim, the rescuers lift the victim to the edge of the window as the ground man holding the rope takes up the slack.
5. The victim is then lowered in a hand over hand motion making sure he is clear of the building.



(1986)

AERIAL TRUCK - ROPE RESCUE

- #1 Man - working man at the end of the aerial ON THE GROUND.
- #2 Man - working man ON THE AERIAL TURNTABLE.
- #3 MAN - aerial truck driver and control operator.

OPERATING SEQUENCE

- #3 Man - will position his vehicle in the correct location to accomplish the rescue.
 - lock brakes and block wheels.
 - engage hydraulic system, set jacks.
 - extend ladder, while still in ladder bed, 2 or 3 rungs to permit placing or snatch block on correct ladder rung.
 - is responsible for the operation of the ladder controls during rescue evolution.
- #1 Man - will place the snatch block on the top fly, end rung or nearest the end rung (due to different rung sizes).
- #2 Man - will bring the Kernmantle Rope to the turntable of the aerial truck.
 - take the rope from the bag and complete two turns around the solid base bar at the butt of the aerial ladder.
 - take the end of the rope the length of the ladder and place the rope over the solid unprotected rung, then under the second rung from the end, then through the snatch block.

MAKE SURE THAT THE SNATCH BLOCK SAFETY LOCK IS IN THE CLOSED POSITION.
- #1 Man - place the slings on the stretcher, hooks turned in.
 - secure the Kernmantle Rope from the snatch block, to the stretcher sling "O" ring using a Bowline Knot with a Half Hitch, leaving 5 metres of tail rope extending from the Half Hitch. The tail can act as a guide rope "out from the incident area".
 - attach a second 30 metre rope using a Bowline to act as a guide rope which is controlled by the #1 Man.

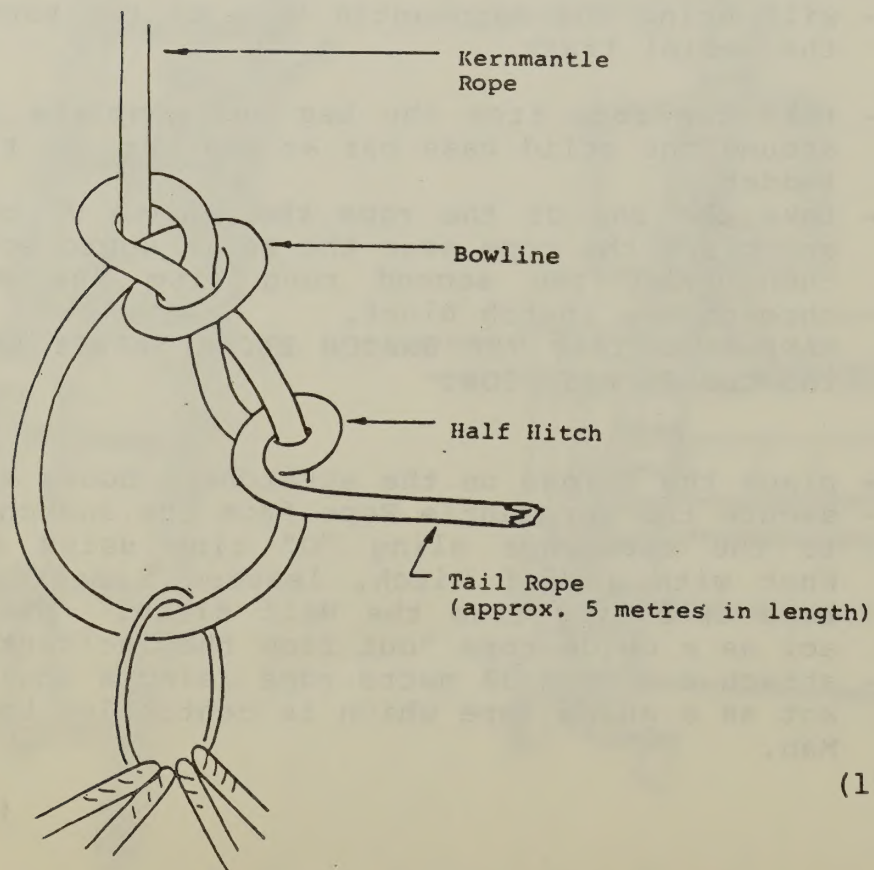
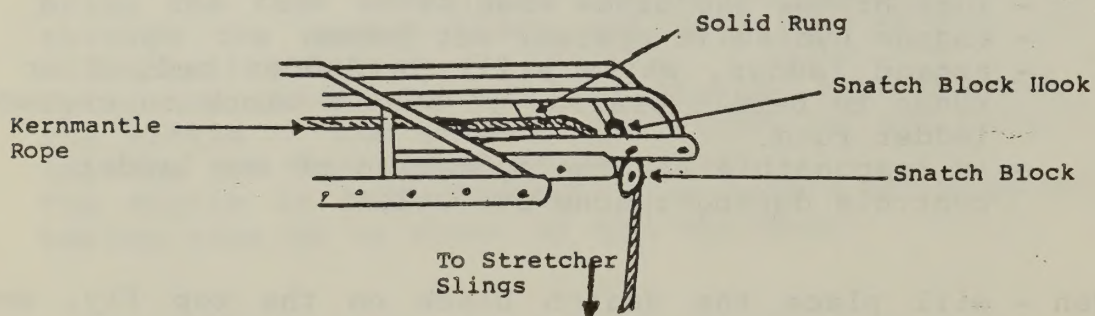
(1986)

Officer in charge will direct the entire evolution.

#3 Man - will operate the apparatus controls.

#2 Man - will control the Kernmantle Rope from the turntable.

#1 Man - will control the stretcher guide rope, from the ground.



(1986)

17. LADDER SAFETY

- Check proper climbing angle
- Make sure ladder is secure at top and bottom
- Check ladder locks are on
- Check poles to make sure they are set properly
- Climb smoothly and rhythmically
- Always tie in with a leg lock or a safety belt when working from a ladder
- Don't overload a ladder
- Choose proper ladder for the job
- Make sure ladders are not raised into electrical wires

Foot Position

1. Initial raising from ground position - butt men butt with inside foot.
2. Ladder in position for raising or lowering flys - all men butt the ladder with the outside foot.
3. Lowering ladder into the building - beam men butt with inside foot.

Hand Position

- Most comfortable position when beaming a ladder.

Passing

- Outside hand under the beam and inside hand on the rungs (pass on right - man ascending).

Polemen

- Stand to the outside of poles.

(1986)

Lowering Flies

- Hand over hand on halyard (don't let rope slide through hands).

Moving A Ladder In The Vertical Position

- Lift on the main ladder rungs not on the fly ladder.

Narrow Passageway

- Men on the right side move forward and men on the left side drop back (hands on rungs).

Watching The Tip

- Watch the top of the ladder when raising or lowering.

Carrying Tools Up A Ladder

- When carrying hand tools up a ladder, slide hand carrying tools up the beam of the ladder.

18. MAINTENANCE OF GROUND LADDERS

- Check all parts weekly when cleaning.
- Check all parts after use.

"CAUTION: The strength of metal ladders depends on the hardness of the metal. In the case of metal ladders, the aluminum alloy's hardness was obtained by a heat treating process. Metal ladders which have been exposed to heat should be placed out of service until a hardness test can be performed."

NOTE: FOR ADDITIONAL INFORMATION, REFER TO I.F.S.T.A. MANUAL.

(1986)

REPORT

DATE: _____

1. Introduction

The purpose of this report is to provide a detailed analysis of the data collected during the experiment. The data was collected over a period of six months, from January to June 2023. The experiment was conducted in a controlled environment, and the results are presented in the following sections.

The first section of the report describes the experimental setup and the data collection process. The second section presents the results of the experiment, and the third section discusses the implications of the findings. The fourth section provides a conclusion and recommendations for future research.

The data collected during the experiment shows a clear trend of increasing values over time. This trend is consistent across all the data points collected. The results of the experiment are presented in the following table:

The table shows that the values increase steadily over the six-month period. This increase is likely due to the factors mentioned in the introduction. The results of the experiment are consistent with the hypothesis of the study.

1. Introduction

The purpose of this study is to investigate the effects of the proposed system on the performance of the system.

2. Literature Review

The literature review shows that there is a need for a system that can improve the performance of the system.

3. Methodology

The methodology used in this study is a combination of qualitative and quantitative methods.

4. Results

The results of the study show that the proposed system has a positive effect on the performance of the system.

5. Conclusion

The conclusion of the study is that the proposed system is a viable solution for improving the performance of the system.

CHAPTER 8

VENTILATION

1. INTRODUCTION

Ventilation is the systematic removal of heated air, smoke, and gases from a structure, followed by the replacement of a supply of cooler air, which facilitates other fire fighting priorities.

The importance of ventilation cannot be overlooked. It increases visibility for quicker location of the seat of the fire. It decreases the danger to trapped occupants by channeling away hot, toxic gases and it reduces the chance of backdraft. Unfortunately, ventilation may be misunderstood by the public because it requires doing limited damage to a building; but it results in a much larger reduction in damage.

Modern technology requires new emphasis in ventilation. Increased use of plastics will greatly increase the fuel load in all occupancies and one can also expect increases in the amounts of products of combustion produced during fires. Increased insulation in buildings will retain heat better and will raise the temperature of combustibles in the fire area to ignition temperature and may cause flashover to occur much faster. Therefore, the need for ventilation is increased and must be accomplished much sooner than has been practiced in the past.

When a fire officer determines the need for ventilation, the precautions that may be necessary for the control of the fire and the safety of the firefighters must also be considered. There is a need for protective breathing equipment for respiratory protection, and charged hoselines during the ventilation process. The possibility of fire spreading throughout a building and the danger of exposure fires are always present.

2. ADVANTAGES OF VENTILATION

The major objectives of a fire fighting force are to reach the scene of the fire as quickly as possible, rescue trapped victims, locate the fire, and apply suitable extinguishing agents with a minimum of fire, water, smoke, and heat damage. Ventilation during fire fighting is definitely an aid to the fulfillment of these objectives. When proper ventilation is accomplished to aid fire control, there are certain advantages that may be obtained from its application.

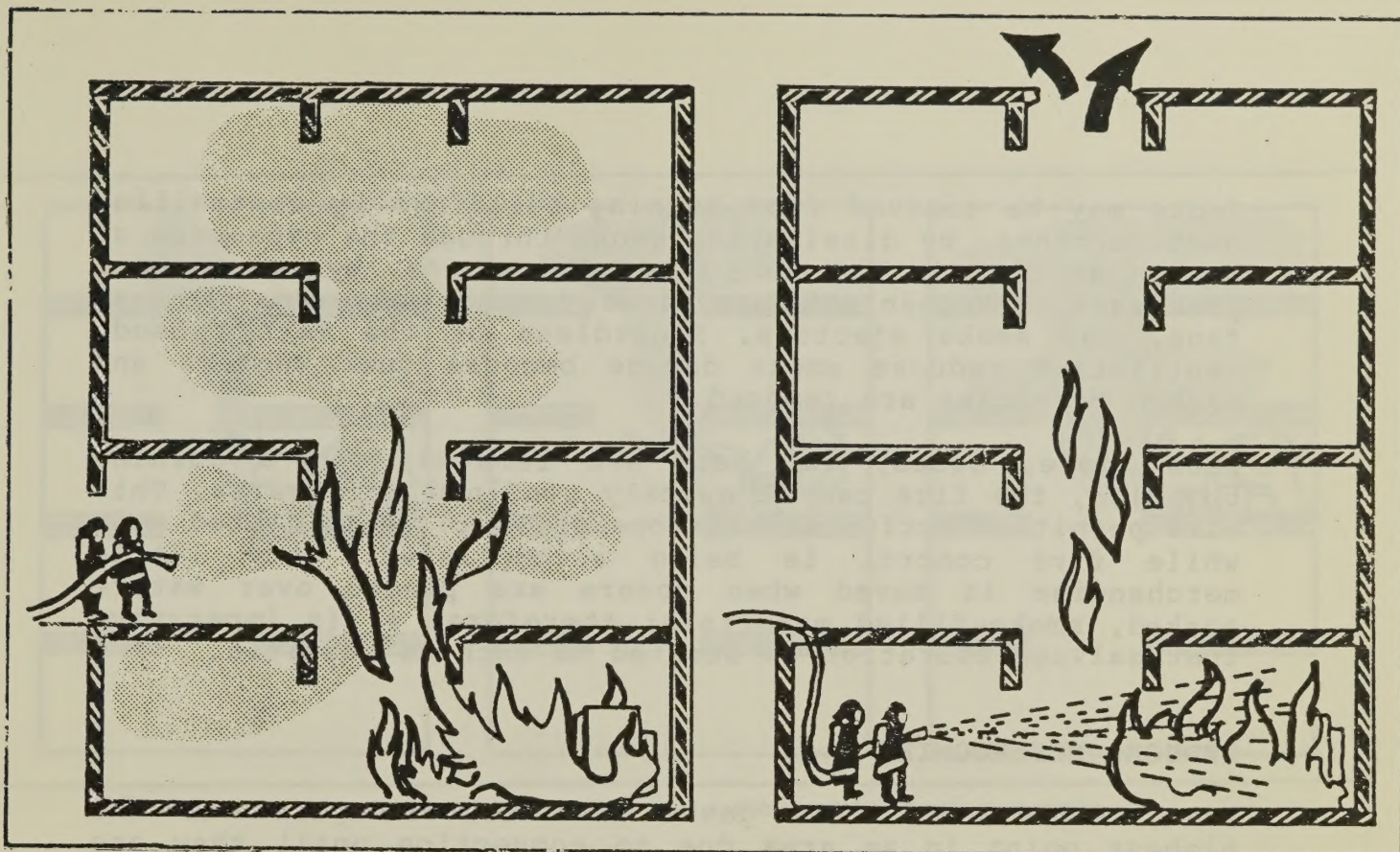
AIDS RESCUE OPERATIONS

Proper ventilation simplifies and expedites the rescue of victims by removing smoke and gases which endanger occupants who are trapped or unconscious, and by making conditions safer for fire fighters.

SPEEDS ATTACK AND EXTINGUISHMENT

The removal of smoke, gases, and heat from a building permits firefighters to more rapidly locate the fire and proceed with extinguishment. Proper ventilation not only reduces the danger of asphyxiation, it also reduces the obstacles which hinder firefighters while they perform fire extinguishment, salvage, rescue, and overhaul procedures, by improving vision and removing the discomfort of excessive heat. When an opening is made in the upper portion of a building during ventilation, a chimney effect is created which draws air currents from throughout the building in the direction of the opening. For example, if this opening is made directly over the fire, it will tend to localize the fire. If it is made elsewhere, it may contribute to the spread of the fire.

(1986)



Smoke and heat make entrance into a building difficult and dangerous. Proper ventilation will remove the heat and smoke

REDUCES PROPERTY DAMAGE

Rapid extinguishment of a fire reduces water damage. Proper ventilation assists in making this damage reduction possible. One method of ventilation that may prove advantageous is applying water in the heated area in the form of water fog. The gases and smoke may be dissipated, absorbed, or expelled by the rapid expansion of the water when it is converted into steam. In addition to removing gases, smoke, and heat, this method also reduces the amount of water that may be required to extinguish the fire (water will expand approximately 1600 times when converted to steam, thereby displacing an equal amount of interior space).

(1986)

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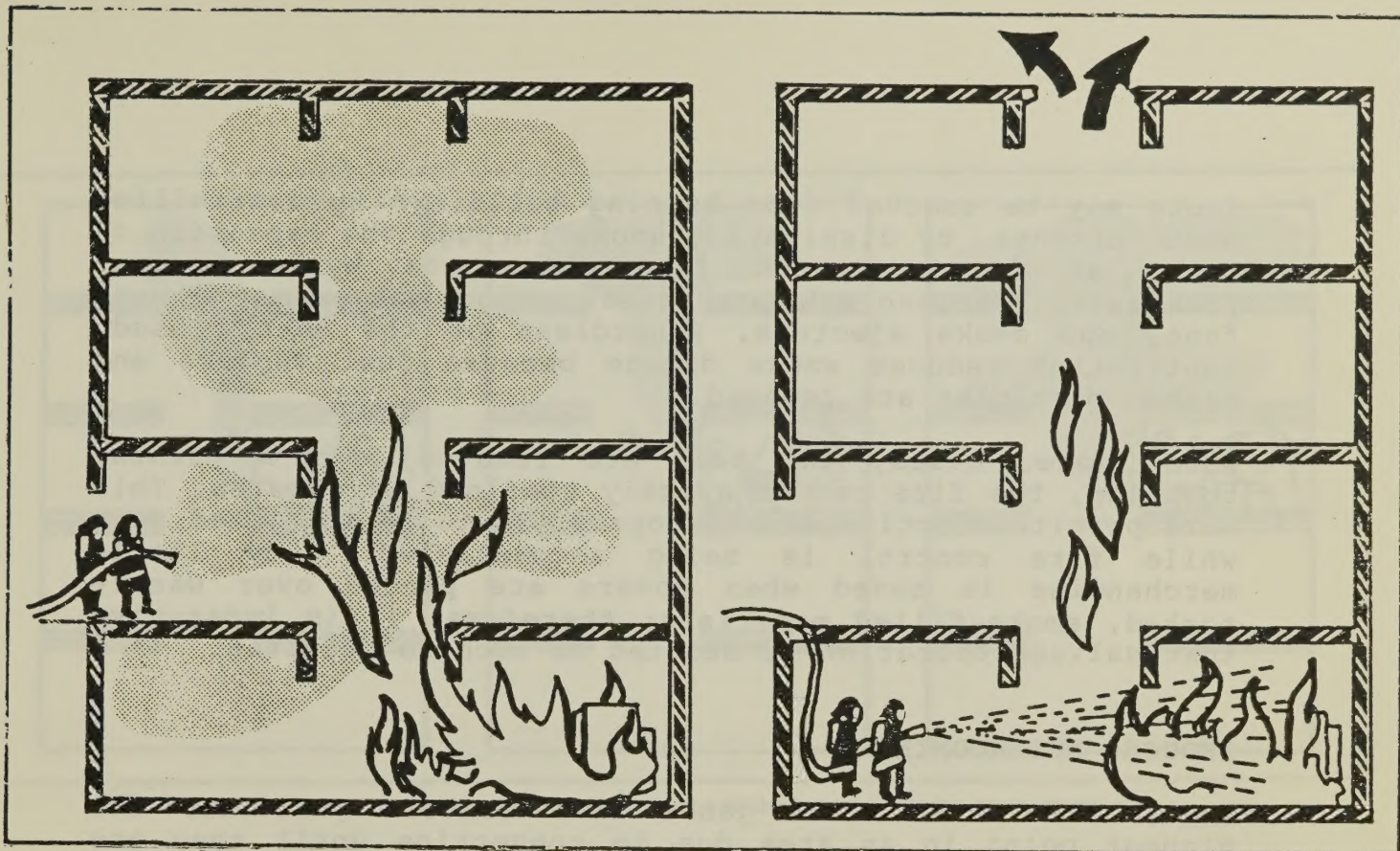
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(1986)

Smoke may be removed from burning buildings by controlling heat currents, by dissipating smoke through the expansion of water as it is turned into steam, or by mechanical processes. Mechanical processes include blowers, exhaust fans, and smoke ejectors. Regardless of the method used, ventilation reduces smoke damage because fuel vapours and carbon particles are removed.

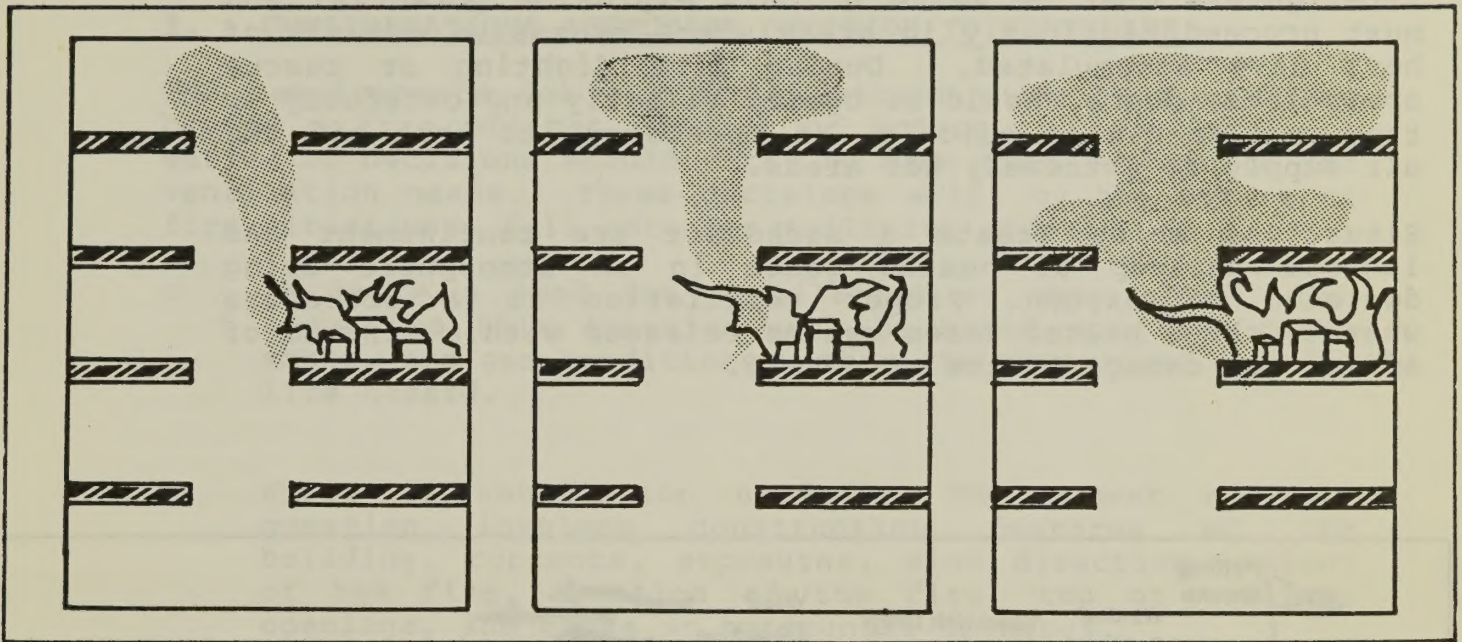
When smoke, gases, and heat are removed from a burning building, the fire can be quickly confined to an area. This will permit effective salvage operation to be initiated even while fire control is being accomplished. Very little merchandise is saved when covers are placed over water-soaked, smoke-filled materials; therefore, it is imperative that salvage operation be started as soon as possible.

REDUCES MUSHROOMING

Heat, smoke, and fire gases will travel upward to the highest point in an area due to convection until they are trapped by a roof or ceiling. As they are trapped and begin to accumulate they bank down and spread laterally to involve other areas of the structure. This phenomenon is generally termed mushrooming.

Proper ventilation of a building during a fire reduces the possibility of mushrooming. It tends to draw the fire to a point by providing an escape for the rising heated gases.

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When smoke, heat, and gases cannot escape they fill all available space from the top, mushrooming down.

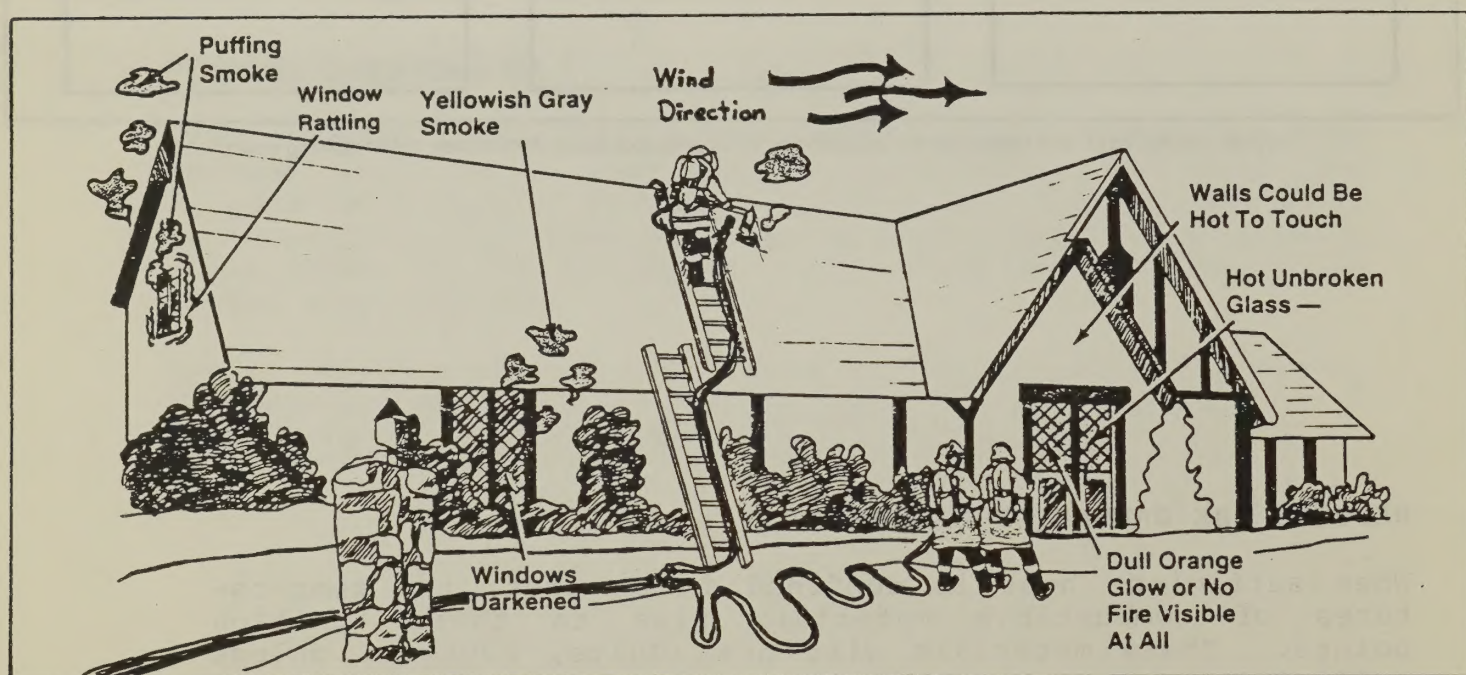
REDUCES THE DANGER OF BACKDRAFT

When sufficient heat is confined in an area, the temperatures of combustible materials rise to their ignition points. These materials will not ignite, however, unless sufficient oxygen is available to support combustion. In this situation, a very dangerous condition exists because the admittance of an air supply (which provides the necessary oxygen) is all that is needed to change the overheated area into an inferno. This sudden ignition is often referred to as backdraft. In order to prevent this critical situation from occurring, top ventilation must be provided to release superheated fire gases and smoke.

(1986)

Firefighters must be aware of this explosion potential and must proceed cautiously in areas where excessive amounts of heat have accumulated. During fire fighting or rescue operations, doors should be opened slightly and carefully so they may be closed quickly, if necessary, to shut off the air supply to extremely hot areas.

Situations which create a backdraft are confinement and intense buildup of heated gases in an atmosphere being depleted of oxygen. Proper ventilation is a procedure whereby these heated gases can be released with a minimum of additional damage to the structure.



Watch for the indications of a backdraft, and if necessary, perform vertical ventilation.

(1986)

3. CONSIDERATIONS AFFECTING DECISION TO VENTILATE

The requirements for a plan of attack must be considered before a fire officer directs or orders to ventilate. A series of decisions should first be made that pertain to the ventilation needs. These decisions will, by the nature of fire situations, fall into the following order:

- o Is there a need for ventilation at this time? The answer to this question must be based upon the heat, smoke, and gas conditions within the structure, and the life hazard.
- o Where is ventilation needed? The answer to this question involves construction features of the building, contents, exposures, wind direction, extent of the fire, location of the fire, top or vertical openings, and cross or horizontal openings.
- o What type of ventilation should be used? The answer to this question may be derived from a fire officer's knowledge of the following three methods of ventilation: (1) Providing an opening for the passage of air between interior and exterior atmospheres; (2) Using the application of water fog and the expansion of water into steam to displace contaminated atmospheres; and (3) Using forced air ventilation.

4. VISIBLE SMOKE CONDITIONS

Smoke conditions will vary according to how burning has progressed. A free-burning fire must be treated differently than one which is in the smoldering stage. Smoke accompanies most ordinary forms of combustion, and it differs greatly with the nature of the substances of materials being burned. The density and colour of the smoke is in a direct ratio to the amount of suspended particles. A fire that is just beginning and is consuming wood, cloth, and other ordinary furnishings will ordinarily give off gray-white or blue-white smoke of no great density. As the burning progresses, the density may increase, and the smoke may become darker because of the presence of large quantities of carbon particles.

(1986)

Black smoke is usually the result of burning rubber, tar, roofing oil, or other flammable liquids. It has been said that brown smoke may indicate the oxides of nitrogen fumes and that gray-yellow smoke is a danger signal of approaching backdraft. A firefighter should remember that the materials that smoke contains can only be determined by chemical analysis. Although the colour of the smoke may be of some value in determining what is burning, smoke colour is not always a reliable indicator. It is sometimes quite easy for firefighters to classify what is burning by distinctive odours, especially during the early stages of the fire. Smoke from burning rubber, rags, and pine wood, feathers, or grass all have a characteristic odour. As the smoke grows more dense and the firefighter is exposed to greater quantities, irritation to the nasal passages soon decreases an ability to recognize odours.

5. THE BUILDING INVOLVED

Knowledge of the building involved is a great asset when making decisions concerning ventilation. Building type and design are the initial factors to consider in determining whether horizontal or vertical ventilation should be accomplished. The number and size of wall openings, the number of stores, staircases, shafts, and dumbwaiters, ducts, roof openings, the availability and involvement of exterior fire escapes and exposures are determining factors. The extent to which a building is connected to adjoining structures also has a bearing on the decision. In-service company inspection and pre-fire planning may provide more valuable and detailed information.

6. HIGH-RISE-BUILDINGS

A major consideration in high-rise buildings is the danger to occupants from heat and smoke. High-rise buildings are normally occupied by hospitals, hotels, apartments, and business offices. In any case, a great number of people may be exposed to danger.

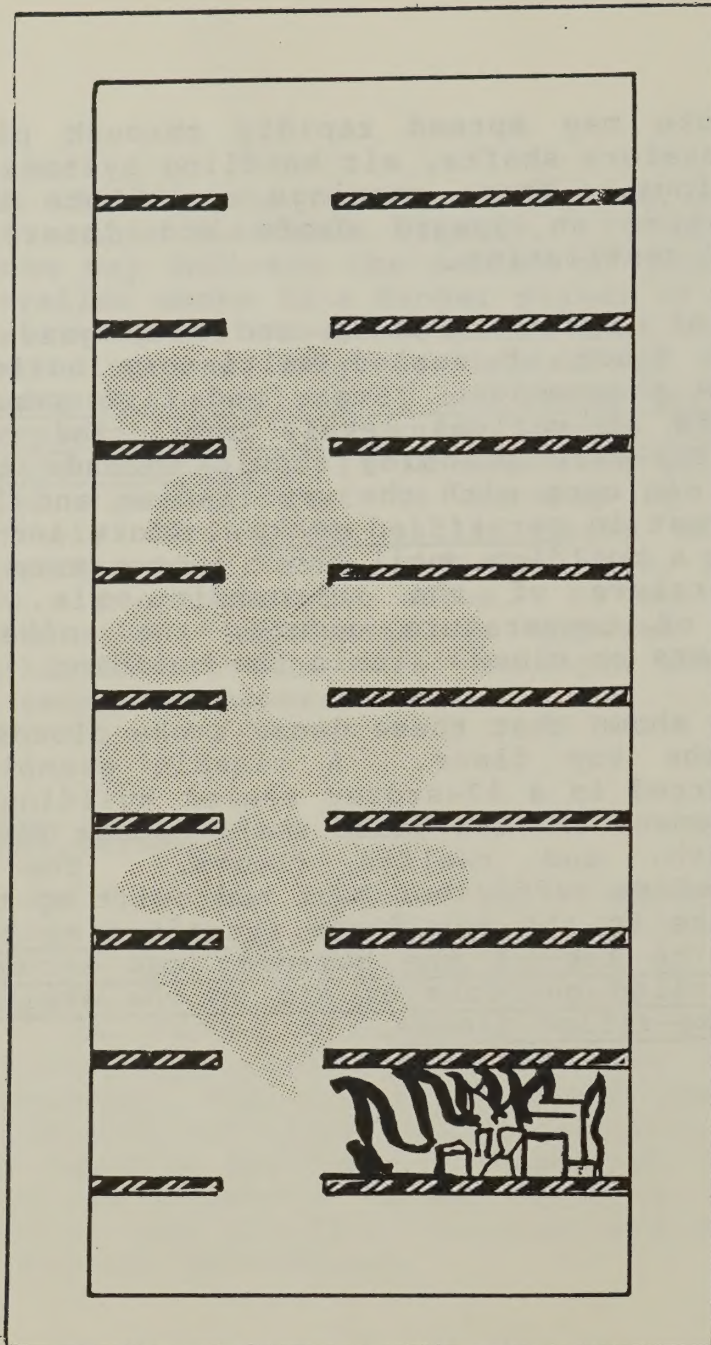
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Fires and smoke may spread rapidly through pipe shafts, stairways, elevators shafts, air handling systems, and other vertical openings. These openings contribute to a "stack effect", creating an upward draft and interfering with evacuation and ventilation.

The creation of layers of smoke and fire gases on floors below the top floor of sealed multistory buildings is a relatively new phenomenon. Smoke and fire gases produced will accumulate at various levels until the building is ventilated. Pre-fire planning should include tactics and strategy that can cope with the ventilation and life hazard problems inherent in stratified smoke. Smoke and fire gases travel through a building until their temperature is reduced to the temperature of the surrounding air. When this stabilization of temperature occurs, the smoke and fire gases form layers or clouds within the building.

Experience has shown that these dense smoke clouds form at a level below the top floor. A classic example of this formation occurred in a 17-storey sealed building. The fire was in the basement and the dense smoke clouds formed on the tenth, eleventh, and twelfth floors. The fire was extinguished before sufficient heat had built up to move the stratified smoke to the top floor. Ventilating this cooled smoke out of the top of the building was accomplished by creating controlled currents of air up the stairshafts and across the smoke-filled floors.

(1986)



In high-rise buildings smoke and gases cool as they rise and stratify or layer before reaching the top. This variant of mushrooming creates a "lid" for other products of combustion. The level above the fire where this occurs varies with a number of factors including fuel, intensity and size of the fire, types of smoke channels, height of the building, and weather.

(1986)

The mushrooming effect, which is usually expected on top floors, does not occur in tall buildings until sufficient heat is built up to move the stratified smoke and fire gas clouds that have gathered on lower floors in an upward direction.

Ventilation in a high-rise building without specific plans for the effective use of manpower, equipment, and extinguishing agents, should not be attempted. Consideration must be given to the fact that the manpower demand for this type of building is approximately four to six times as great as required for a normal residence fire. In most instances, ventilation must be accomplished horizontally with the use of mechanical ventilation devices. Protective breathing equipment will be in great demand since every firefighter will have to be completely equipped with self-contained breathing apparatus. The problems of communication and coordination between the various attack and ventilating teams become more involved as the number of participants increase.

Top ventilating in modern tall buildings must be considered during pre-fire planning. In many buildings only one stair shaft pierces the roof. This vertical "chimney" must be used to ventilate smoke, heat, and fire gases from various floors. Before the doorways on the fire floors are opened and the stair shaft is ventilated, the door leading to the roof must be blocked open or removed from its hinges.

MEASURES FOR LIFE SAFETY OF HIGH RISE BUILDINGS

Design measures to control smoke movement in high buildings have been developed. Fourteen measures relate to limiting or installing smoke movement only.

This is accomplished by fully sprinklered buildings, pressurized stairwells, pressurized elevator shafts, and controlled air handling equipment that will shut down on activation of the alarm system (can be manually operated in certain buildings if required).

Removing smoke from a building can be done by one of the following ways:

(1986)

- a) By using the built-in facilities, such as smoke shafts, building exhaust systems, windows, wall panels, etc.
- b) Many buildings can be vented by using the Principles of Measures M. (controlling smoke movement in high rise buildings).

THEORY OF MEASURES M SMOKE CONTROL

Measures M is a combination of controlled vertical and horizontal ventilation.

A flow of cool air is introduced into the stairwell shaft at ground level, this pressurizes the shaft. (Hot air rises, cool air comes in at lower sections).

OPERATION FOR CONTROLLED SMOKE REMOVAL IN EXISTING BUILDINGS

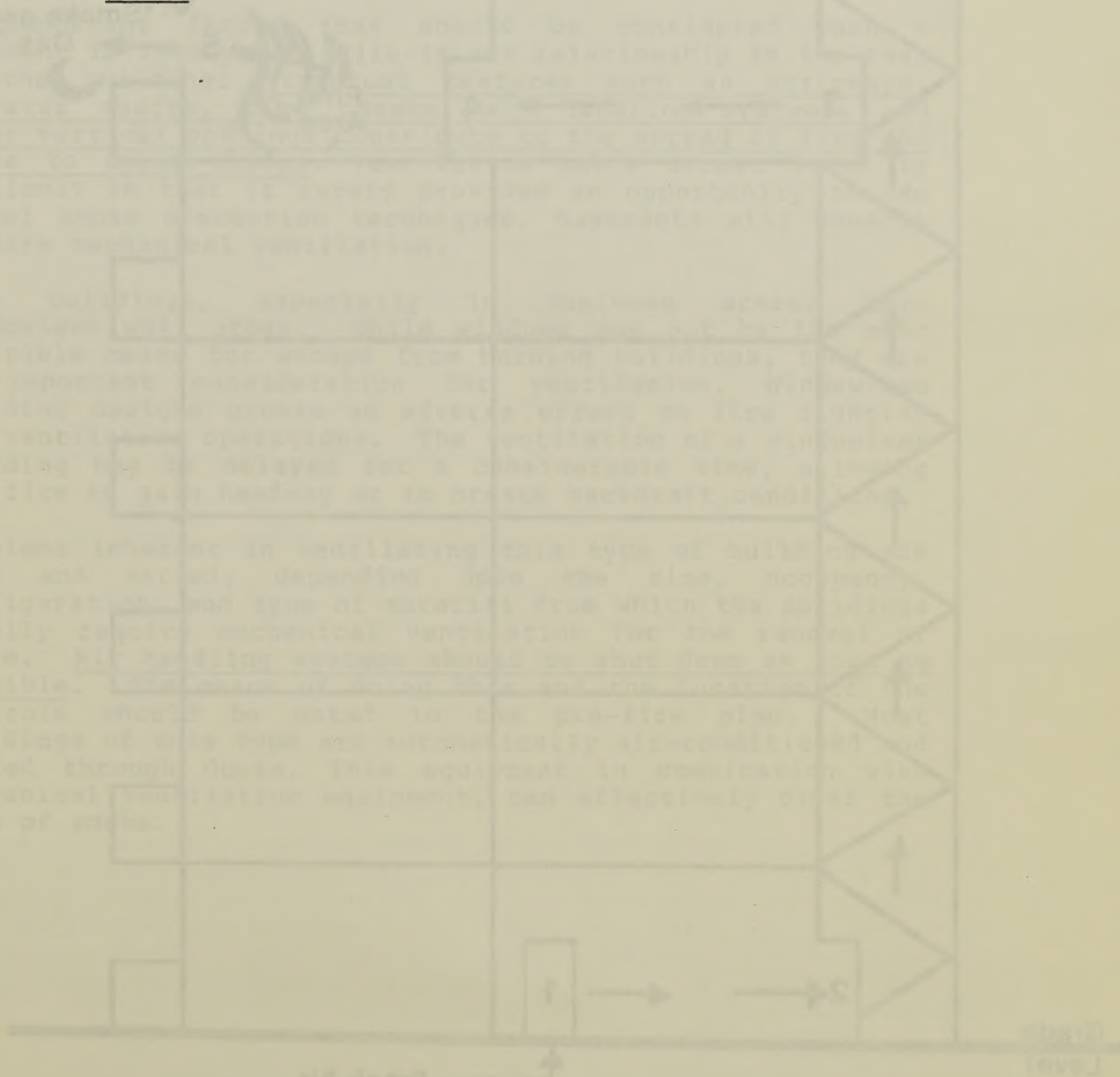
- 1. Open a door at grade level to the outside atmosphere.
- 2. Open a door at the bottom of the stairwell at grade level.
- 3. Open door leading from stairwell to fire floor.
- 4. Open door to apartment or unit involved in fire.
- 5. Open balcony doors or windows in unit or apartment.

NOTE: By following steps 1 and 2, cool air is allowed into the stairshaft, thus pressurizing it. By following steps 3, 4, and 5, the fire floor and area is ventilated by a continuous flow of cool fresh air from the outside at grade level.

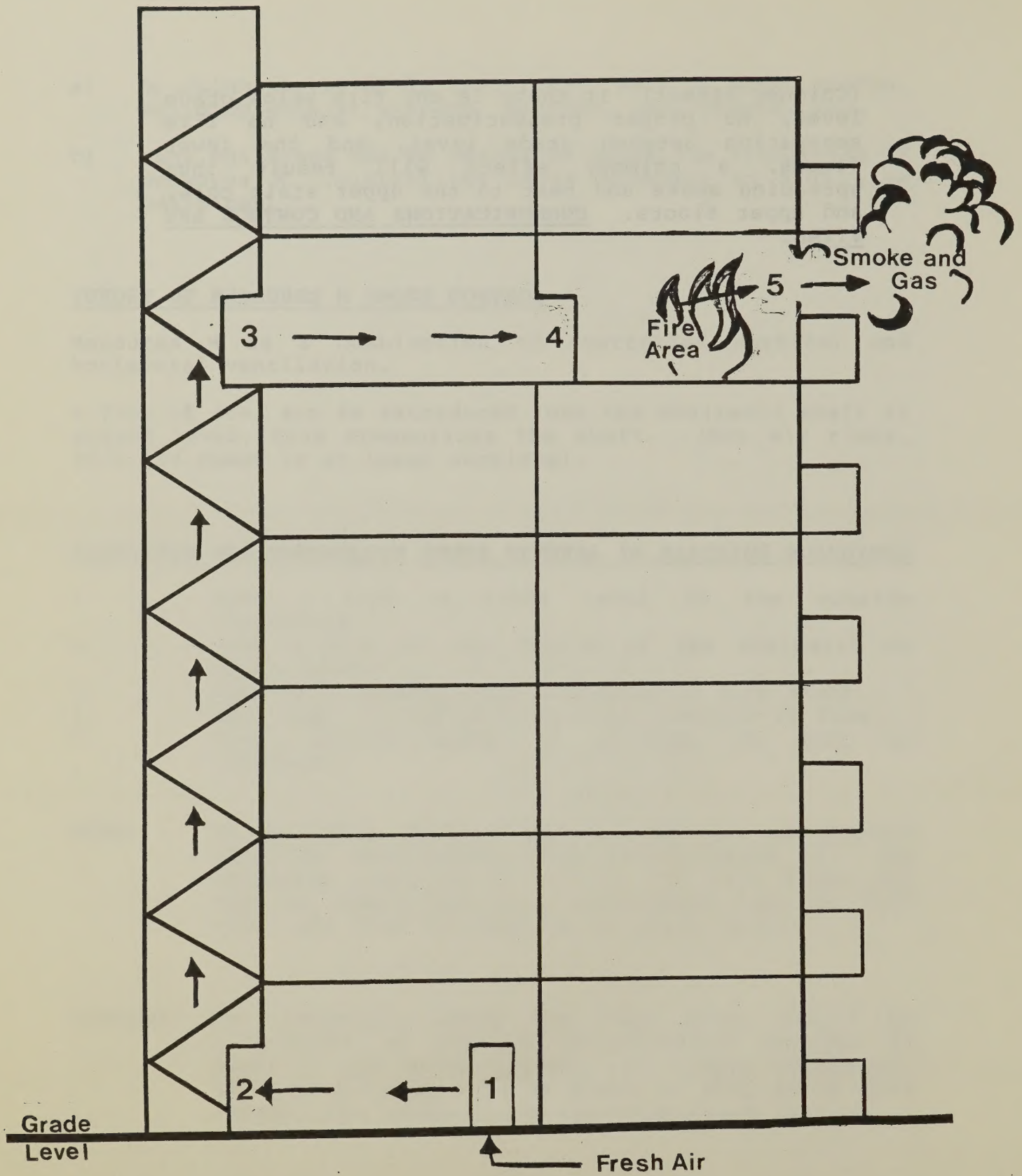
CAUTION: The stairwell above the fire floor should be controlled to prevent unauthorized opening of doors in the above floors. If a door is opened, the air currents will be drawn to that point thus drawing the smoke to the uncontaminated areas.

(1986)

(Chimney Effect) If there is any fire below grade level, no proper pressurization, and no fire separation between grade level, and the lower floors, a chimney effect will result thus spreading smoke and heat to the upper stair core, and upper floors. COMMUNICATIONS AND CONTROL ARE VITAL.



(1986)



(1986)

7. BASEMENTS AND WINDOWLESS BUILDINGS

Most outside entrances to basements may be blocked or secured by iron gratings, steel shutters, wooden doors, or combinations of these for protection against weather and burglars. All of these features serve to impede attempts at natural ventilation.

An important factor that should be considered when a basement is involved in fire is its relationship to the rest of the building. Structural features such as stairways, elevator shafts, pipe chases, air handling systems, and other vertical openings contribute to the spread of fire and smoke to upper floors. Ventilation below street level is difficult in that it rarely provides an opportunity to use normal smoke evacuation techniques. Basements will usually require mechanical ventilation.

Many buildings, especially in business areas, have windowless wall areas. While windows may not be the most desirable means for escape from burning buildings, they are an important consideration for ventilation. Windowless building designs create an adverse effect on fire fighting and ventilation operations. The ventilation of a windowless building may be delayed for a considerable time, allowing the fire to gain headway or to create backdraft conditions.

Problems inherent in ventilating this type of building are many and varied, depending upon the size, occupancy, configuration, and type of material from which the buildings usually require mechanical ventilation for the removal of smoke. Air handling systems should be shut down as soon as possible. The means of doing this and the location of the controls should be noted in the pre-fire plan. Most buildings of this type are automatically air-conditioned and heated through ducts. This equipment in combination with mechanical ventilation equipment, can effectively clear the area of smoke.

(1986)

8. LIFE HAZARDS

Dealing with the danger to human life is of utmost importance. Certain fire conditions may suggest that ventilation come first to draw away heat and smoke, or that the spreading flames must be attacked immediately; sometimes both must be done simultaneously. The first consideration is the safety of occupants. The life hazards are generally reduced in an occupied building involved by fire if the occupants are awake. If however, the occupants were asleep when the fire developed and are still in the building, either of two situations may be expected: first, they may have been overcome by smoke and gases; second, they might have become lost in the building and are probably panicky. In either case, proper ventilation will be needed in conjunction with the rescue operations.

In addition to the hazards that endanger occupants, there are potential hazards to firefighters and rescue workers. The type of structure involved, whether natural openings are adequate, and the need to cut through roofs, walls, or floors (combined with other factors) add more problems to the decision process.

The hazards that can be expected from the accumulation of smoke and gases in a building include:

- o Obscurity caused by dense smoke
- o Presence of poisonous gases
- o Lack of oxygen
- o Presence of flammable gases

Another consideration facing firefighters is flammability of the materials and contents within a building. While these combustible materials may be heated above their ignition temperature, they may not burn because of the lack of oxygen. The hazard lies in the fact that preheated combustibles will burst into a free-burning fire when provided with a supply of fresh air.

(1986)

9. LOCATION AND EXTENT OF THE FIRE

In most instances ventilation should not be carried out until the location of the fire is established. Opening for ventilation purposes before the fire is located may spread the fire throughout areas of the building that would not otherwise have been affected. Smoke that is coming out of the floor since it may be on a lower floor or even, perhaps, in the basement. Likewise, smoke that is gently flowing from an opening is not necessarily close to the seat of the fire. Obviously extensive roof ventilation may be impractical or extremely dangerous if the location of the fire is such that vertical ventilation will draw the fire into parts of the building which are not involved.

The fire may have travelled some distance throughout a structure by the time fire fighting forces arrive, and consideration must be given to the extent of the fire, as well as to its location. The severity and extent of the fire usually depend upon the kind of fuel, the time it has been burning, installed fire protection devices, and to which stage the fire has progressed is a primary consideration in determining ventilation procedures. Some of the ways by which vertical extension occurs are as follows.

- o Through stairwells, elevators, and shafts by direct flame contact or by convected air currents.
- o Through partitions and walls and upward between the walls by flame contact and convected air currents.
- o Through windows or other outside openings where flames extend to other exterior openings and enters upper floors (lapping).
- o Through ceilings and floors by conduction of heat through beams, pipes, or other objects that extend from floor to floor.
- o Through ceilings and floors by direct flame contact.
- o Through floor and ceiling openings where sparks and burning material fall through to lower floors.
- o By the collapse of floors and roofs.

(1986)

10. SELECTING THE PLACE TO VENTILATE

There is no rule of thumb in selecting the exact point at which to open a roof except "as directly over the fire as possible". Many factors will have a bearing on where to ventilate. Some of them are:

- o The availability of natural openings such as skylights, ventilator shafts, monitors, and hatches.
- o Location of the fire and the direction which the chief officer wishes it to be drawn.
- o Type of construction.
- o Wind direction.
- o The extent of progress of the fire and the condition of the buildings and its contents.
- o Bubbles or melting roof tar.
- o Indications of roof sag.

The effect that ventilation will have on the fire, the consequences its release will have on exposures, the department's state of readiness, and the ability to protect exposures, prior to actually opening the building, should be considered when determining the place to ventilate.

Before ventilating a building, a fire officer must provide manpower and adequate fire control facilities, because the fire may immediately increase in intensity when the building is opened. These resources should be provided for both the building involved and other exposed buildings. As soon as the building has been opened to permit hot gases and smoke to escape an effort to reach the seat of the fire for extinguishment should be made. Entrance should be made into the building as near the fire as possible, if wind direction will permit. It is at this opening that charged hoselines should be positioned in case of violent burning or an explosion. Charged lines should also be made available at other points where openings are to protect buildings that are likely to be endangered because of their exposure to the one involved.

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11. VERTICAL VENTILATION

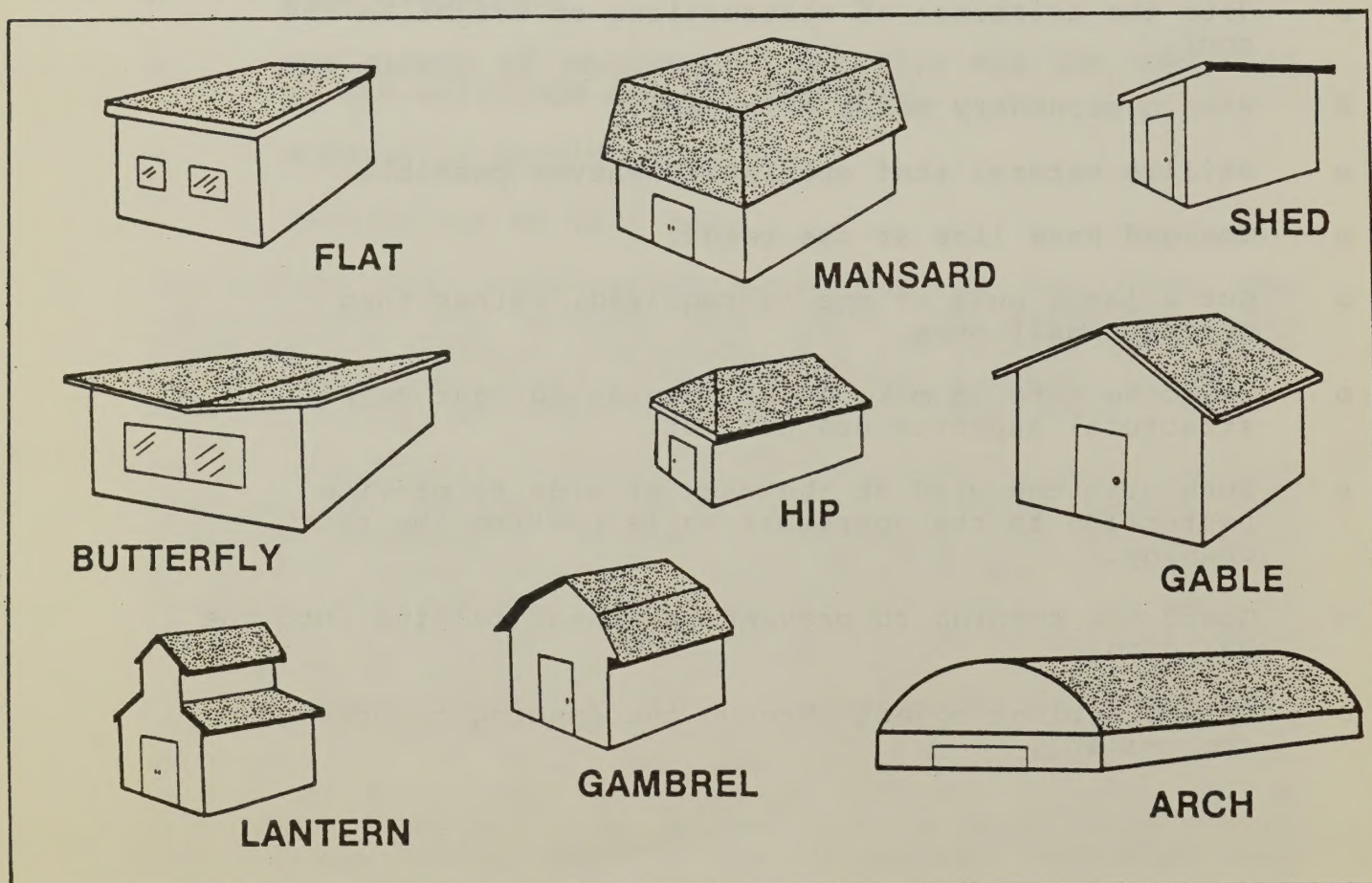
After the fire officer has considered the type of building involved, the location and extent of the fire, moved manpower and tools to the roof, observed safety precautions, and has selected the place to ventilate, the operation is still not complete. Top level ventilation involves all of these factors plus the following precautions and procedures which the officer in charge must consider and practice to be successful.

- o Coordinate with ground and attack companies.
- o Observe the wind direction with relation to exposures.
- o Note the existence of obstructions or weight on the roof.
- o Plan a secondary means of escape.
- o Utilize natural roof openings whenever possible.
- o Charged hose line at the ready.
- o Cut a large hole if one is required, rather than several small ones.
- o Exercise care in making the opening so that main structural supports are not cut.
- o Work with the wind at the back or side to provide protection to the operators while cutting the roof opening.
- o Guard the opening to prevent personnel falling into the building.
- o Extend a blunt object through the opening to break out the ceiling.

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OPENING ROOFS

In order to properly ventilate a roof, the firefighter must understand the basic types and designs of roofs. Roof coverings may be wood shingles, composition shingles, composition roofing paper, tile, slate, or a built-up tar and gravel surface. The selection of a proper roof covering is important from a fire protection standpoint because it may be subjected to sparks and blazing brands. The firefighter is concerned with three prevalent types of roof construction: flat, pitched, and arched styles. Some of the more common styles are the flat, gable, gambrel, shed, hip, mansard, dome, lantern and butterfly.



Common roof types.

(1986)

SAFETY PRECAUTIONS

The officer aloft should be in constant communication with the chief officer at the scene. Portable radios are most adaptable to this type of communication. Responsibility on the roof includes insuring that only the required openings are made, coordinating the crew's efforts with those of the firefighters who are inside, and insuring the safety of all personnel who are assisting in the opening of the building. Some of the safety precautions that should be practiced include.

- o Providing a secondary means of escape.
- o Preventing personnel from walking on spongy roofs.

NOTE: This is usually a sign that structural members have been weakened. (If it is necessary to open a weakened roof, a roof ladder serves to distribute the firefighter's weight over a larger area).

- o Securing a lifeline to any firefighter who is to enter a weakened roof area.
- o Protecting personnel from sliding and falling. (Wydra Belt).
- o Exercising caution in working around electric wires and guy wires.
- o Insuring that the person making the opening is standing to the windward side of the cut and wearing the proper protective equipment.
- o Not allowing other persons within range of the axe.
- o Starting power tools on the ground to insure operation at the site of the cut at upper areas. It is important that the tool be shut off before hoisting or raising the tool to these upper areas.
- o Being on the lookout for indications of weakening structures or other hazards.
- o Exercising caution, especially when using power tools, not to cut or weaken supporting structural members.

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NATURAL ROOF OPENINGS

Natural roof openings may exist on various types of roofs in the form of scuttle hatches, skylights, monitors, ventilating shafts, and even stairway doors.

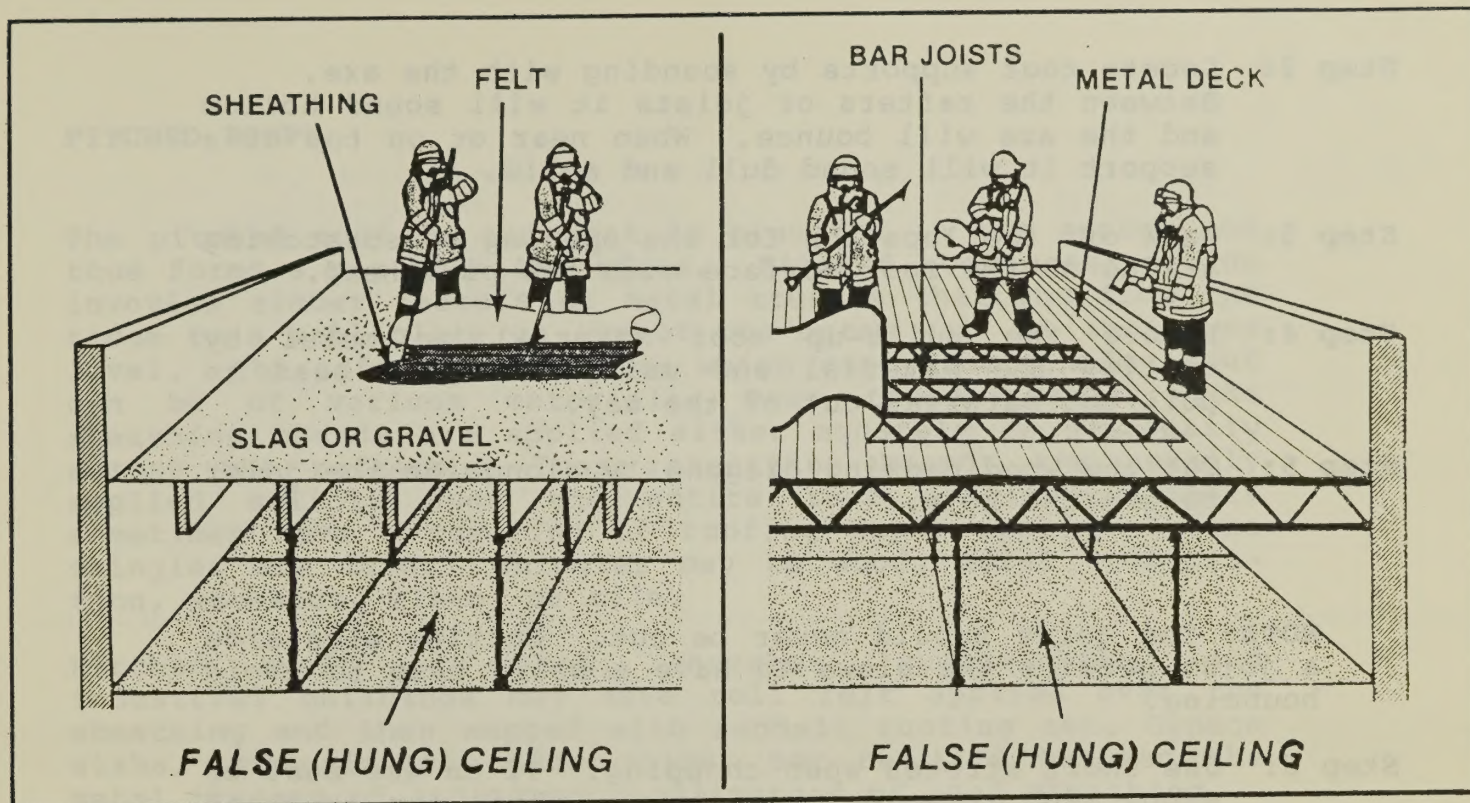
These can be used for ventilation. Make sure the natural roof opening is in the proper location and is of the proper size.

FLAT ROOFS

Flat roofs are more common to mercantile buildings, industrial buildings, and multiple dwelling apartments than to individual buildings. This type of roof ordinarily has a slight slope toward the rear of the building and is frequently pierced by chimneys, vent pipes, shafts, scuttles, and skylight. The roof may be surrounded and divided by parapets, and it may support water tanks, air-conditioning equipment, antennas, and other obstructions which may interfere with ventilation operations.

The structural part of the flat roof is generally similar to the construction of a floor which consists of wooden, concrete, or metal joists covered with sheathing. The sheathing is covered with a layer of waterproofing material and an insulating material. Instead of joists and sheathing construction, flat roofs are sometimes poured reinforced concrete or precast gypsum or concrete slabs set within metal joists.

(1986)



Flat roofs are supported generally by wood or metal joists with wood or metal decking, plywood panels, or poured gypsum covered by a water-tight roof surface.

The materials used in flat roof construction in some ways determine its ability to be cut with a fire axe. When cutting through a roof, the firefighter should make the opening rectangular or square to facilitate repairs being more easily made. One large opening at least 1.2 by 1.2m is much better than several small ones. A procedure for opening a wood joist or rafter roof with an axe is suggested in the following sequence:

Step 1: Use the following factors to determine the location for the opening to be made:

- o Location of intense fires
- o Highest point on roof
- o Direction of wind
- o Existing exposures
- o Extent of fire
- o Obstructions

(1986)

- Step 2:** Locate roof supports by sounding with the axe. Between the rafters or joists it will sound hollow and the axe will bounce. When near or on top of a support it will sound dull and solid.
- Step 3:** Mark off the location for the opening by scratching a line on the roof surface with the pick head.
- Step 4:** Remove the built-up roof material or metal by cutting the material and using the pick head to pull the material out of the way.
- Step 5:** Cut the wood decking diagonally alongside the joist toward the hole.

NOTE: The joist should never be cut. Cutting alongside a joist permits the blows to have a solid base to avoid bouncing.

- Step 6:** Use short strokes when chopping. If an axe must be swung high to apply more force, check for overhead obstructions and other firefighters,.
- Step 7:** Pry up the roofboards with the pick end of the axe. After opening has been cut in the roof, push the blunt end of a pike pole, plaster hook, or some other suitable tool through the roof opening to open the ceiling below.

Power equipment for opening roofs is most useful and often provides a means by which ventilation procedures can be accelerated.

(1986)

PITCHED ROOFS

The pitched roof is one that is elevated in the center and thus forms a pitch to the edges. Pitched roof construction involves timber rafters or metal trusses that run from the ridge to a wall plate on top of the outer wall at the eaves level. The rafters or trusses which carry the sloping roof can be of various materials. Over these rafters, the sheathing boards are applied either squarely or diagonally across the rafters. These sheathing boards are usually applied solidly over the entire roof. Pitched roofs sometimes have a covering of roofing paper applied before shingles are laid. Shingles may be wood, metal, composition, asbestos, slate, or tile.

Pitched roofs on barns, churches, supermarkets, and industrial buildings may have roll felt applied over the sheathing and then mopped with asphalt roofing tar. Gypsum slabs, approximately 50mm thick, may be laid between the metal trusses of a pitched roof instead of wood sheathing.

Pitched roofs have a more pronounced downward incline than those of flat roofs. This incline may be gradual or steep. The procedures for opening roofs are quite similar to those for flat roofs except that additional precautions to prevent slipping must be taken. Suggested steps for opening pitched roofs are as follows:

- Step 1:** Place a roof ladder on the roof and locate the position where the opening is to be made. Bounce the axe on the roof to sound for solid supports or rafters (use Wydra-Belt when working on roof).
- Step 2:** Move the roof ladder to either side of the selected location and use the ladder for support. The location should usually be at the highest point of the roof.
- Step 3:** Rip off the shingles or roofing felt sufficiently to permit the initial cut to be made. (In some cases, it is best to first remove all shingles or roofing felt from the entire area where the hole is to be made).

(1986)

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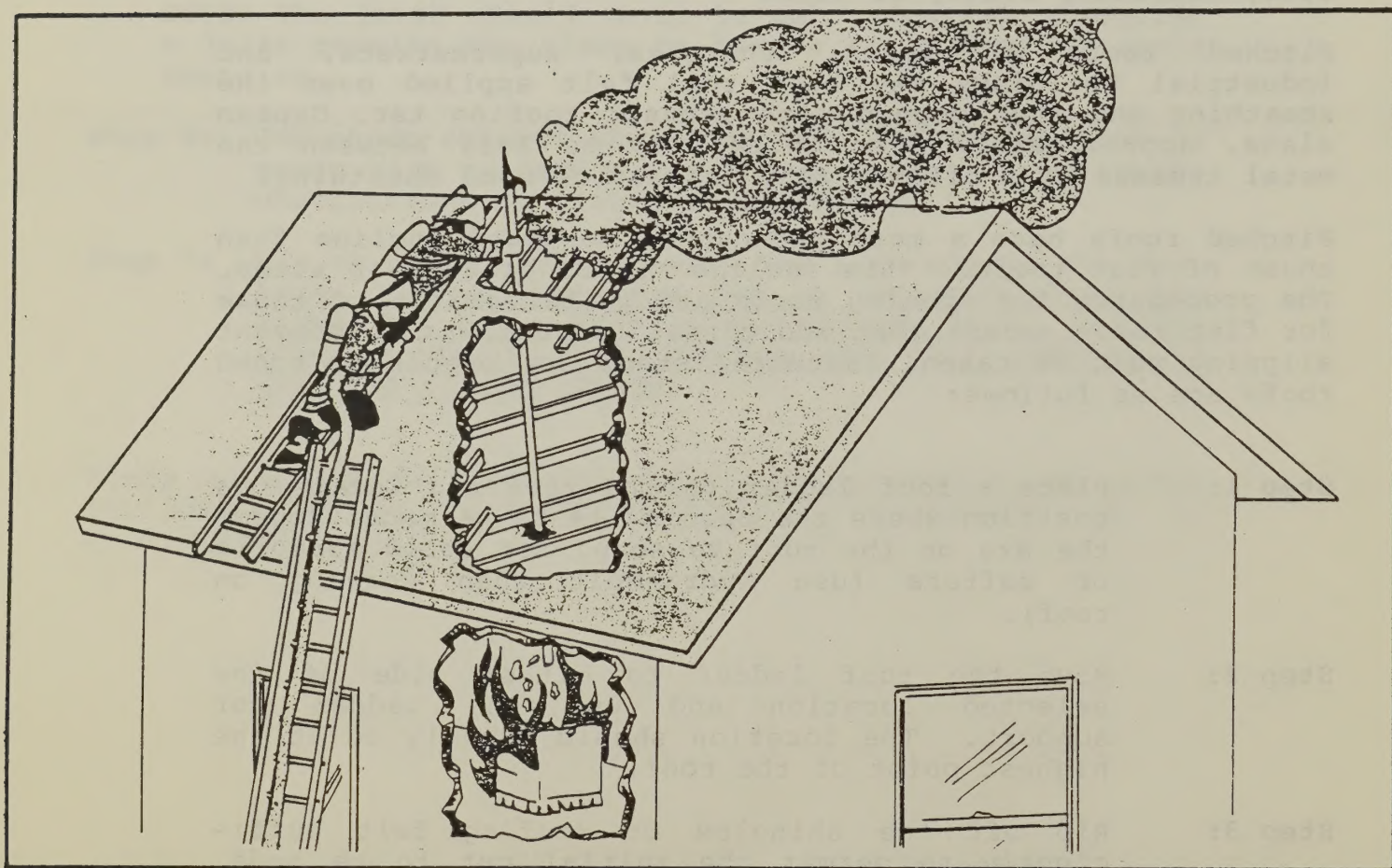
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(1986)

- Step 4:** Cut the sheathing along the side of a rafter the distance required for the opening. The opposite side of the opening may then be cut in a like manner. (The opening should be square or rectangular).
- Step 5:** Remove sheathing boards with the pick of the axe or some other suitable tool.
- Step 6:** Push the blunt end of a pike pole or other long handled tool through the hole to open the ceiling.



When opening a pitched roof cut down along the rafters, cut parallel to the ridge, and remove both the roofing materials and the ceiling below

(1986)

ARCHED ROOFS

Cutting procedures for opening arched roofs are the same as for flat or pitched roofs except that it is doubtful that a roof ladder can always be used on an arched roof. Long straight or extension ground ladders and aerial ladders may sometimes prove satisfactory by placing the ladder as flat on the roof as possible. Regardless of the method used to support the firefighter, the procedure is difficult and dangerous because of the curvature of the roof. Proper safety precautions must be observed.

TRENCHING

Trench ventilation sometimes referred to as strip ventilation, is a form of ventilation when properly done, will often prevent the horizontal spread of heat, smoke and fire throughout a large building.

This type of ventilation has been found to be very successful in controlling fires in buildings such as:

schools

apartment houses

motels

rest homes

factories

having long, open undivided attic areas.

Trenching is done by making a 1 metre wide opening in the roof, then running this cut across the entire width of the building.

Firefighters must remember to open the ceiling below once they have completed opening the roof.

(1986)

IT IS IMPERATIVE THAT THE TRENCH LOCATION BE PLANNED AND SUFFICIENT TIME BE ALLOWED TO PERMIT THE COMPLETION OF THE OPENING BEFORE THE FIRE REACHES THE TRENCH.

The opening, when completed, will allow a damper effect to be established, drawing heat and products of combustion out of the opening, preventing a horizontal spread of fire.

Interior hose lines should be placed in uninvolved areas below the trench cut and directed toward the fire area to assist in stopping the fire spread. Other streams can be used to protect the roof.

Many times fire will appear at the opening in the roof.

AT NO TIME SHOULD A HOSELINE OR ELEVATED STREAM BE DIRECTED INTO THIS OPENING.

By directing water onto the flame, all of the heat and smoke will be forced back into the building.

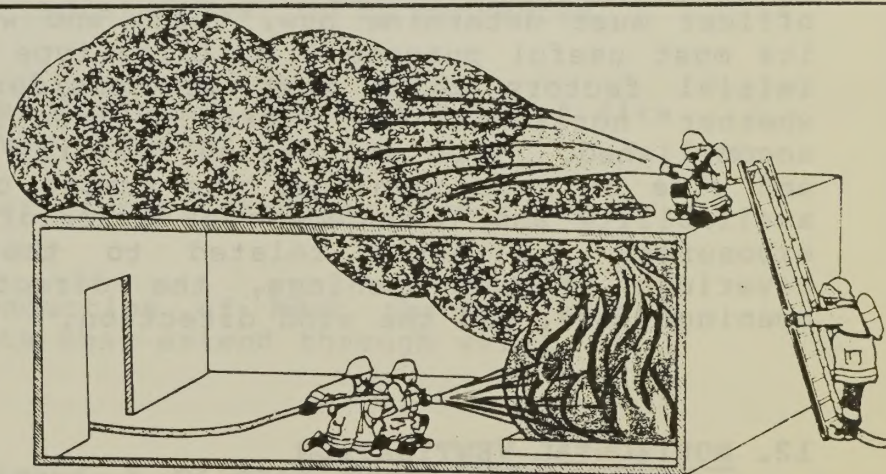
PRECAUTIONS AGAINST UPSETTING ESTABLISHED VERTICAL VENTILATION

When vertical ventilation is accomplished, the natural convection of the heated gases creates upward currents which draw the fire and heat in the direction of the upper opening. Fire fighting teams take advantage of the improved visibility and less contaminated atmosphere to attack the fire at its lower point. If the "stack effect" is interrupted, the heat, smoke, and steam back up, hampering extinguishment efforts. Stack effect is the vertical natural air movement throughout a building. The magnitude of stack effect is determined by the differences in temperature and the densities between the air inside and outside the building. Some common factors that can destroy the effectiveness of ventilation are as follows: improper use of forced ventilation, breakage of glass, improperly directed fire stream, breakage of skylights, explosions, a burn through, and additional openings between the attack team and the upper opening.

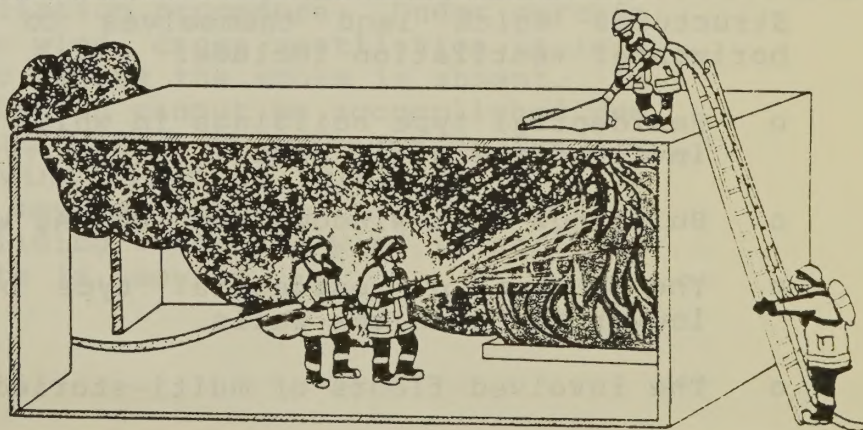
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Elevated streams are frequently used to cut down sparks and flying brands from a burning building or to reduce the thermal column of heat over a building. When elevated or handline streams are projected downward through a ventilation opening or used to reduce the thermal column to a point where ventilation is hindered, they either destroy or upset the orderly movement of fire gases from the building. An upset of this nature can materially affect firefighters who may be working at various levels on floors below. Streams that are being operated just above ventilated openings should be projected slightly above the horizontal plane. In this position they will help cool thermal column and extinguish sparks. The movement of the stream may even increase the rate of ventilation.

CORRECT APPLICATION



INCORRECT APPLICATION



When streams are directed downward through a ventilation opening, they destroy or upset the process. They should be directed slightly above the horizontal plane across the opening.

(1986)

Vertical ventilation cannot be the solution to all ventilation problems for there may be many instances where its application would be impractical or impossible. Only prompt and accurate size-up, based on a thorough understanding of the many variables which affect, or are affected by, ventilation can provide the answer to the following two questions:

- o Is ventilation required?
- o What type is most appropriate in this instance?

In addition to selecting the method of ventilation, a fire officer must determine how, when, and where it will serve its most useful purpose. Building type and design are the initial factors which must be considered in determining whether horizontal or vertical ventilation should be accomplished. Type and design features include the number and size of wall openings, the number of stories, and the availability and involvement of exterior fire escapes, and exposures. Directly related to these are protective coverings of the openings, the direction in which the openings face, and the wind direction.

12. HORIZONTAL VENTILATION

Structures which lend themselves to the application of horizontal ventilation include:

- o Residential type buildings in which the fire has not involved the attic area.
- o Buildings with windows high up the wall near the eaves.
- o The attics of residential type buildings which have louver vents in the walls.
- o The involved floors of multi-storied structures.
- o Buildings with large unsupported open spaces under the roof in which the fire is not contained by fire curtains and in which the structure has been weakened by the effects of burning.

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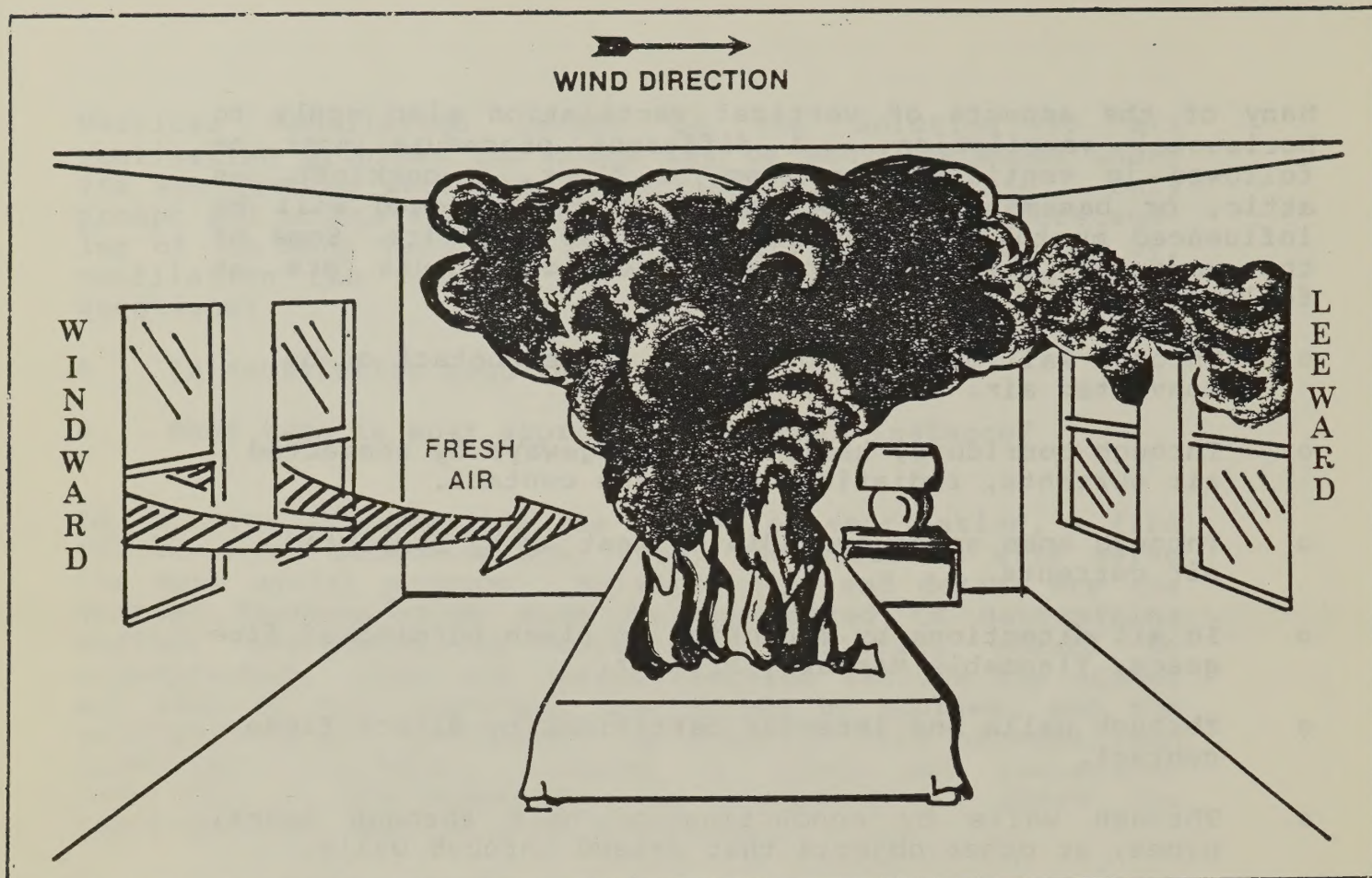
Many of the aspects of vertical ventilation also apply to horizontal ventilation. A different procedure must be followed in ventilating a room, a floor, a cockloft, an attic, or basement. The procedure to be followed will be influenced by the location and extent of the fire. Some of the ways by which horizontal extension occurs are as follows:

- o Through wall openings by direct flame contact or by convected air.
- o Through corridors, halls, or passageways by convected air currents, radiation, and flame contact.
- o Through open space by radiated heat or by convected air currents.
- o In all directions by explosion or flash burning of fire gases, flammable vapours, or dust.
- o Through walls and interior partitions by direct flame contact.
- o Through walls by conduction of heat through beams, pipes, or other objects that extend through walls.

WEATHER CONDITIONS

Weather conditions are always a primary consideration in determining the proper ventilation procedure. Under certain conditions, when there is no wind, cross ventilation is less effective since the force to remove the smoke is absent. In other instances cross ventilation cannot be accomplished due to the danger of wind blowing toward an exposure or feeding oxygen to the fire. The wind plays an important role in ventilation. Its direction may be designed as windward or leeward. The side of the building where the wind is striking is the windward, the opposite is leeward.

(1986)



For optimum cross ventilation, open upper windows on the leeward side, then open lower windows on the windward side

EXPOSURES

Since horizontal ventilation does not normally release heat and smoke directly above the fire, some routing is necessary. Firefighters should be aware of internal exposures as well as external exposures. The routes by which the smoke and heated gases would travel to the exit may be the same corridors and passageways which occupants will be using for evacuation. Therefore, the practice of horizontal ventilation without first considering occupants and rescue procedures may block the escape of occupants. The theory of horizontal ventilation is basically the same as that of vertical ventilation in-as-much-as the release of the smoke and the heat is an aid in fighting the fire and reducing damage.

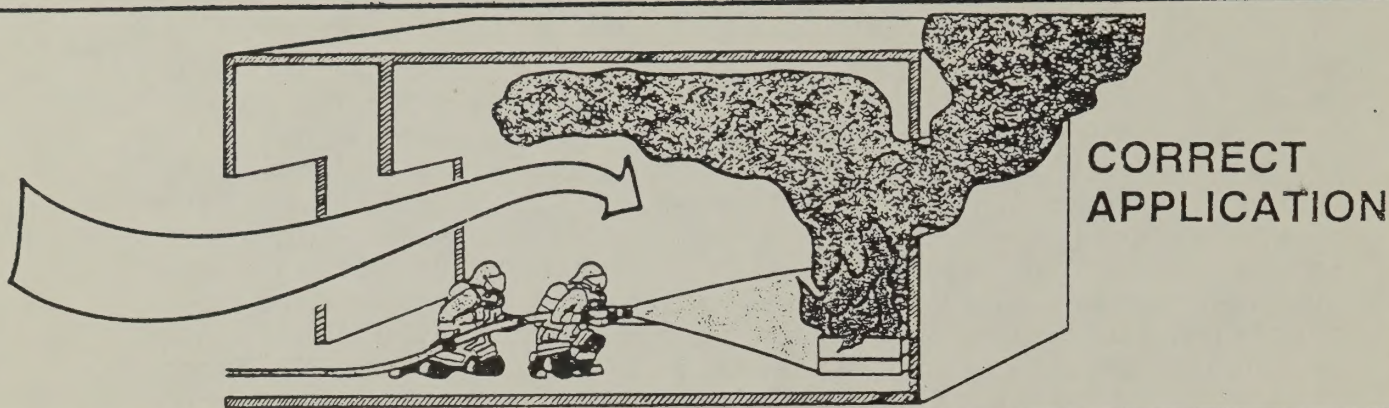
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Outside exposures include those previously mentioned plus those which are peculiar to horizontal ventilation. Since horizontal ventilation is accomplished at a point other than at the highest point of the building, there is the constant danger that the rising heated gases will ignite that portion of the structure which they contact when released. They may ignite eaves of adjacent structures, or be drawn into windows above their liberation point. Unless for the specified purpose of aiding in rescue, a building should not be opened until charged lines are in place at the windward attack entrance point, at the intermediate point where fire, might be expected to spread, and in positions to protect other exposures.

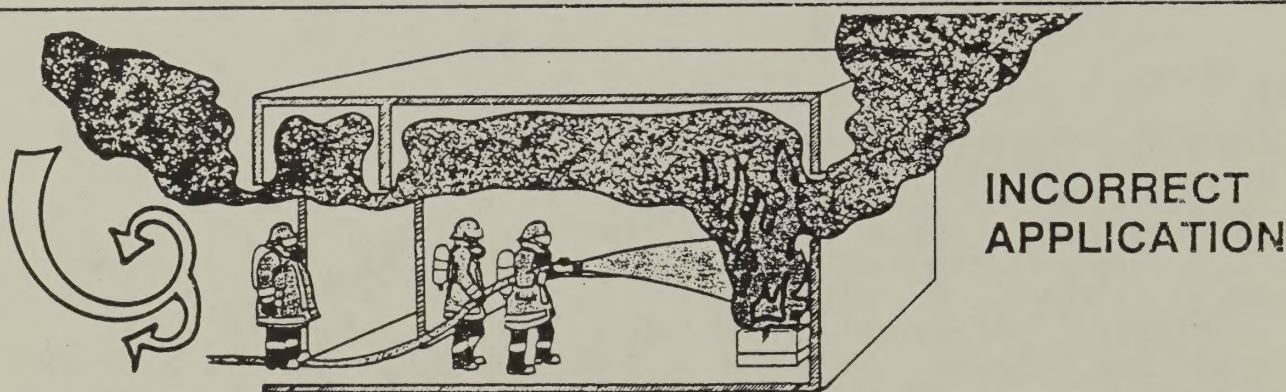
PRECAUTIONS AGAINST UPSETTING HORIZONTAL CROSS VENTILATION

The opening of a door or window on the wrong side of a building may reverse air currents and drive heat and smoke back upon firefighters. Opening doors and windows between the advancing fire fighting crews and the established ventilation exit point will reduce the intake of fresh air from the opening behind the firefighters. Firefighters following established cross ventilation currents are illustrated below. The smoke and heat intensifying as the established current is interrupted by the blocking of fresh air by the firefighter or other obstruction in the doorway is also illustrated below.

(1986)



Fresh air currents can establish beneficial cross ventilation of a smoke-filled room.



If doors or windows opened for fresh air are blocked by a standing firefighter or other obstruction, then smoke and heat will again intensify within the room.

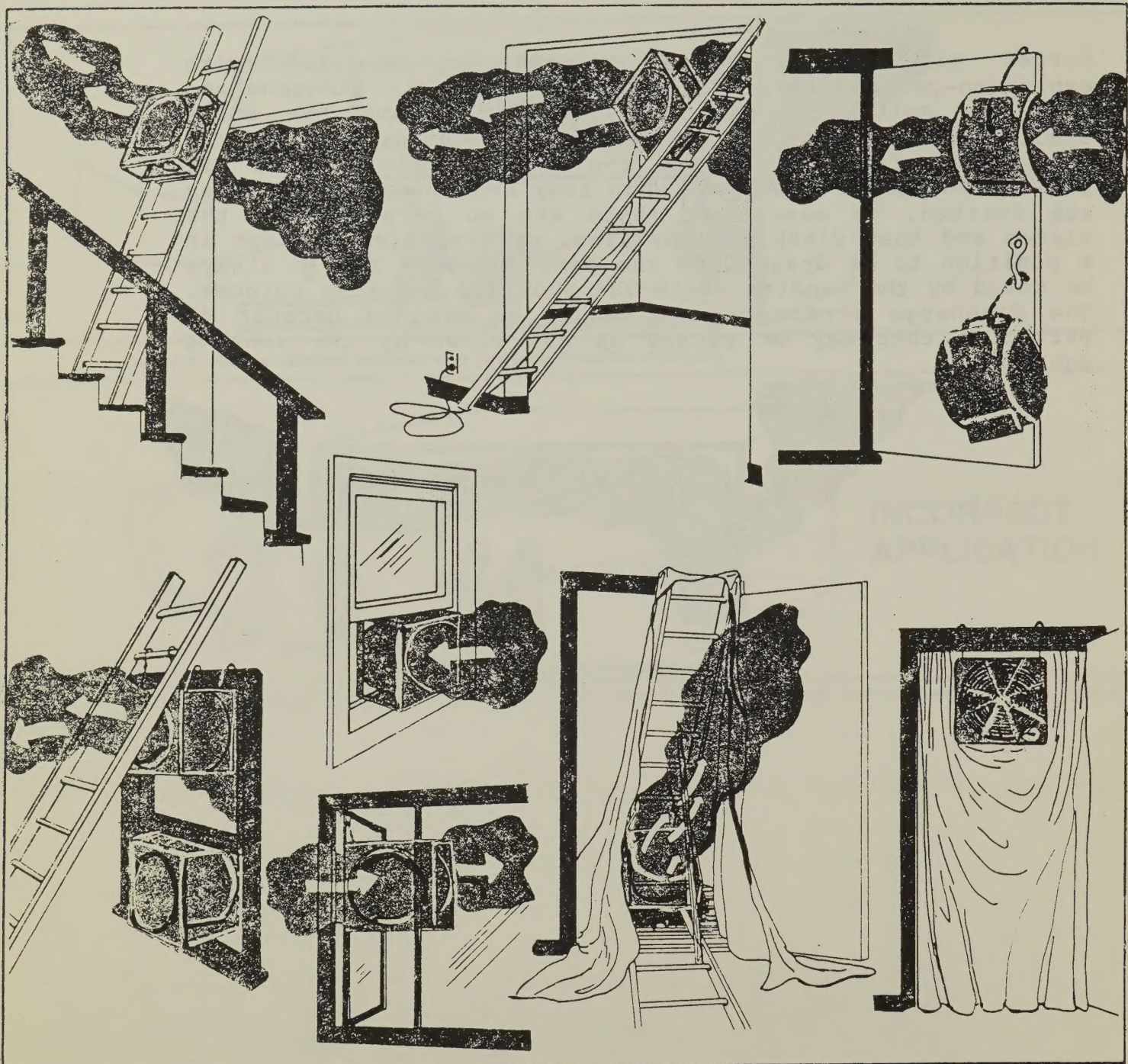
13. FORCED VENTILATION

Ventilation has thus far been considered from the standpoint of the natural flow of air currents, the currents created by fire, and the effect of fog streams. Forced ventilation is accomplished by blowers, fans, or fog streams. The fact that forced ventilation is effective and can be depended upon for smoke removal when other methods are not adequate proves its value and importance.

(1986)

Forced air blowers should always be equipped with explosion-proof motors when used in flammable atmospheres. With the switch in the "on" position, place the smoke ejector in position, then make all necessary electrical connections from the fan to the power supply. Forced air blowers should be shut down when they are moved. Before they are started, be sure that there are no persons near the blades and that clothing, curtains, or draperies are not in a position to be drawn into the fan. Blowers should always be moved by the handles which are provided for this purpose. The discharge stream of air should be avoided because of particles that may be picked up and blown by the venting equipment.

(1986)



Portable smoke ejectors may be placed in any necessary positions with a variety of tools. The higher the placement the better heat will be removed with the smoke.

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SOME ADVANTAGES OF FORCED VENTILATION

Even though fire may not be a factor, contaminated atmospheres must be rapidly and thoroughly ejected. Forced ventilation, if not the only means of clearing a contaminated atmosphere, is always a welcome addition to normal ventilation. Some of the reasons for employing mechanical or forced ventilation are:

- o It insures more positive control.
- o It supplements natural ventilation.
- o It speeds the removal of contaminants, facilitating more rapid rescue under safer conditions.
- o It reduces smoke damage.
- o It promotes good public relations.

DISADVANTAGES OF FORCED VENTILATION

If mechanical or forced ventilation is misapplied or uncontrolled, it can cause a great deal of harm. Forced ventilation requires supervision because of the mechanical force that is behind it. Some of the disadvantages of forced ventilation are:

- o It can move fire along with the smoke and extend it to lateral areas.
- o The introduction of air in such great volumes can cause the fire to spread.
- o It is dependent upon a power source
- o It requires special equipment.

(1986)

FORCED VENTILATION TECHNIQUES

- o Since the basic goal is to develop artificial circulation and pull smoke out fast, the ejector should be placed to exhaust in the same direction as the natural wind.
- o During the early stage of fire, most of the heat, smoke, and congested fumes rise and accumulate near the ceiling. Exhausting smoke ejectors should be placed high for maximum effectiveness in clearing smoke and providing visibility.
- o When air is allowed to recirculate around the sides of the smoke ejector and in and out of nearby openings, it causes a churning action that reduces efficiency. If the area surrounding the fan is left open, atmospheric pressure pushes the air through the bottom of the doorway and pulls the smoke back into the room.

To prevent churning air, cover the area around the unit with salvage covers or other material.

- o Establish desired draft path and keep the airflow in as straight a line as possible. Every corner causes turbulence and decreases efficiency. Avoid opening windows or doors near the exhausting smoke ejector unless opening them definitely increases circulation.
- o Remove all obstacles to the airflow. Even a window screen will cut effective exhaust by half. Avoid blockage of the intake side of the smoke ejector by debris, curtains, drapes, or anything that can decrease the amount of intake air.
- o Have smoke ejectors ready to use when hoselines are in position, and have a charged line at hand when actually placing the ejectors. Since smoke is composed of heated gases, it rapidly condenses and settles on everything in the room or building. Therefore, ejectors should be put into operation as soon as possible after hoselines have been used.

(1986)

- o To speed up the clearing action, place an exhausting smoke ejector on the lee side of the room or building, where it can pull out the remaining smoke and fumes. Then put the blowing ejector in an outside opening on the windward side, where it will admit fresh, clean air. Results are usually most satisfactory when the blowing ejector is located in the lower part of the window or door.
- o Heavier than air gases can be ventilated by placing smoke ejectors as low as possible.

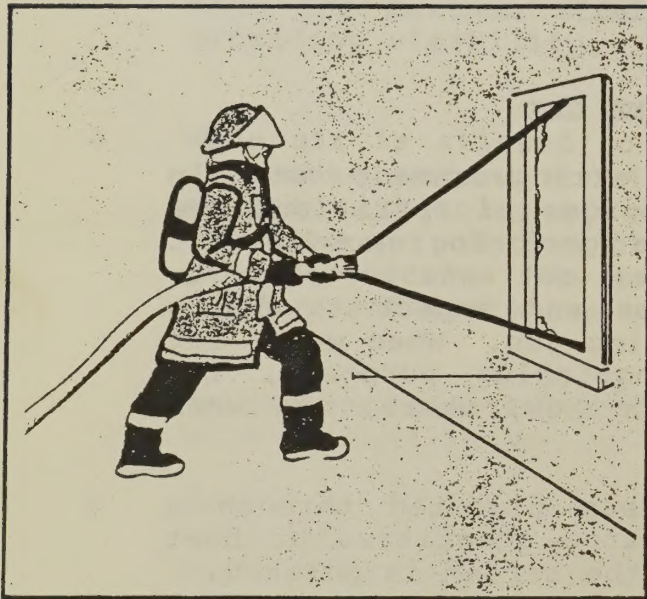
14. USING WATER FOG TO EXPEL SMOKE AND GAS

The use of water fog in fire extinguishment and in ventilation requires a special technique of operation. The mere fact that firefighters have a good fog nozzle that supplies a protective curtain does not enable them to advance into a heavily charged area and expect to do an effective ventilating and extinguishing job. When water fog is used for ventilating and extinguishing purposes, the degree of effectiveness depends upon how, where, and when the fog stream is applied.

It has been found that a fog stream directed through a window or door opening will draw large quantities of heat and smoke in the direction in which the stream is pointed.

Compared with mechanical smoke ejectors, fog streams have been found to remove two to four times more smoke, depending on the type and size of the nozzle, the angle of the fog pattern, and the location of the nozzle in relation to the opening of the building. A fog nozzle stream directed through the opening with a 60° angle fog pattern covering 85 to 90 percent of the opening has been found to provide the best results for ventilation. The nozzle should be about .5 metres from the opening. Larger openings permit greater air-flow, so a door might sometimes be more beneficial than a window. Whatever the size of the opening, wide angle streams should not be used, because when the water path comes close to a right angle to the air path much of the energy that moved the air is lost.

(1986)



When using a fog stream to ventilate, the nozzle set at 60° should be about .5 m from the opening and the pattern should cover 85 to 90 percent of the opening.

NOTE: FOR ADDITIONAL INFORMATION, REFER TO I.F.S.T.A. MANUAL

(1986)

CHAPTER 9

FORCIBLE ENTRY

1. INTRODUCTION

The definition of forcible entry to the Fire Service means the opening of doors, windows, roofs, floors, walls, etc., by mechanical means.

Decisions to perform forcible entry should be made by the officer in charge, but the responsibility for the careful and effective forcible entry falls directly on the firefighter.

Factors In Forcible Entry

In forcible entry there are many factors to be considered, such as; time of day, weather, season, etc., but the four primary reasons might be listed as:

1. Type and construction of the building.
2. Location and extent of fire.
3. Contents of the building.
4. Whether there are occupants or not.

Situations Which May Exist In Areas of Entry Are;

1. Areas where normal openings are locked.
2. Areas where normal openings are blocked.
3. Areas where openings are not provided

(1986)

A skillful method of forcible entry will aid in the saving of lives, cause less damage to property, and result in better public relations.

Points Of Forcible Entry

The four main points of making forcible entry include:

1. Doors - Entry is commonly made through doors
2. Windows - Generally a window is a good point of entry
3. Roofs - Usually opened as part of the ventilation operation
4. Walls - In some instances, it might be more feasible to gain entry by breaching a wall

(1986)

2. GENERAL BUILDING CONSTRUCTION

Most modern buildings have continuous masonry foundations of concrete, brick, or stone upon which the building proper rests. The foundation walls which support frame constructions may extend well above the ground. Exterior walls may be constructed of masonry, veneer, metal, or wood frame. Masonry exterior walls are most desirable from a fire protection point of view. They are usually 20 to 30 cm. thick, depending upon the particular material used.

Masonry veneered walls are essentially frame walls, in which the supporting members are wood with one layer of brick or stone on the exterior. The upright wood supporting members in the walls are called "STUDS" and are usually 5 x 10 cm., spaced at 40 to 60 cm. intervals. The presence of these studs create hollow spaces in the walls through which fire can spread. Fire stops should be provided in these hollow spaces.

Frame walls are constructed of wood throughout, with wood or wall-board sheathing fastened to studs. Over the sheathing is fastened exterior siding, which may be wood, asbestos shingles, stucco, or other types of exterior finish. Frame walls also have hollow spaces in them that are created by the wood studs, which should be blocked off with fire stops.

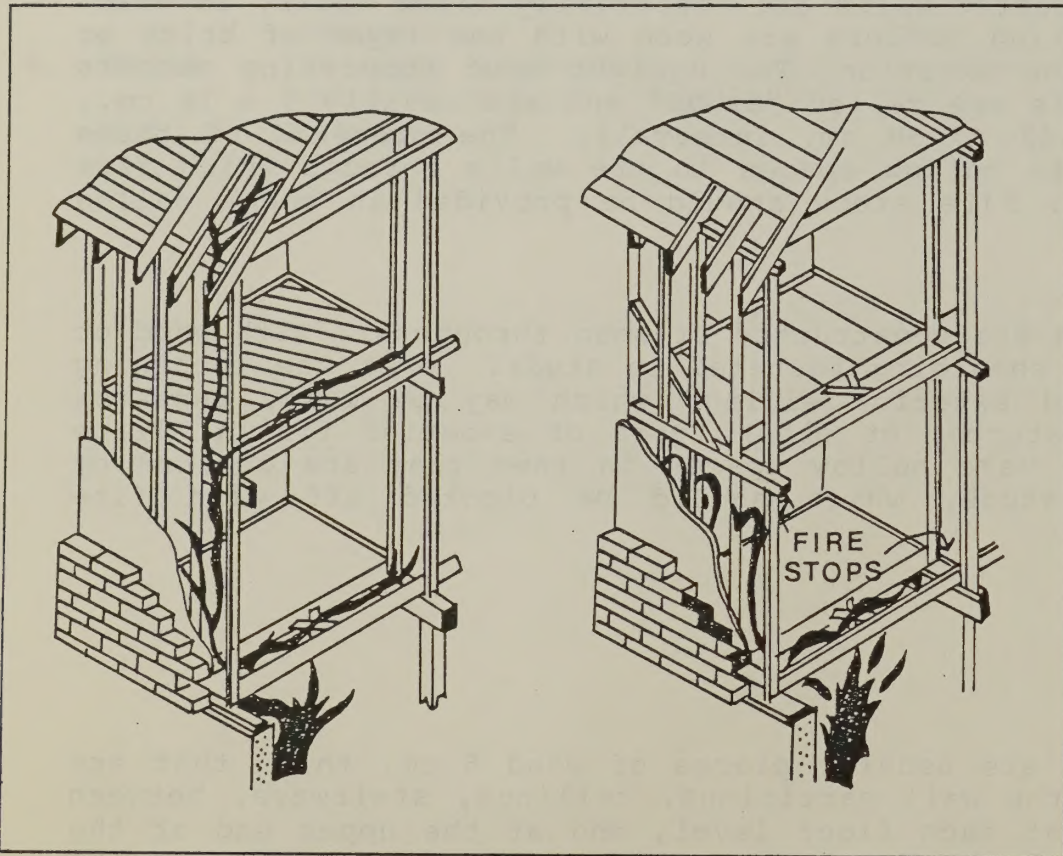
Fire Stops

Fire Stops are usually pieces of wood 5 cm. thick that are placed in the wall partitions, ceilings, stairways, between the studs at each floor level, and at the upper end of the stud channels in the attic. These wooden fire stops cut off the draft within the walls and help prevent the spread of fire and smoke. When fire stops are not used or the spaces are not filled with non-combustible insulation, it is possible for a fire originating in the basement to spread throughout the walls of the building before it is discovered.

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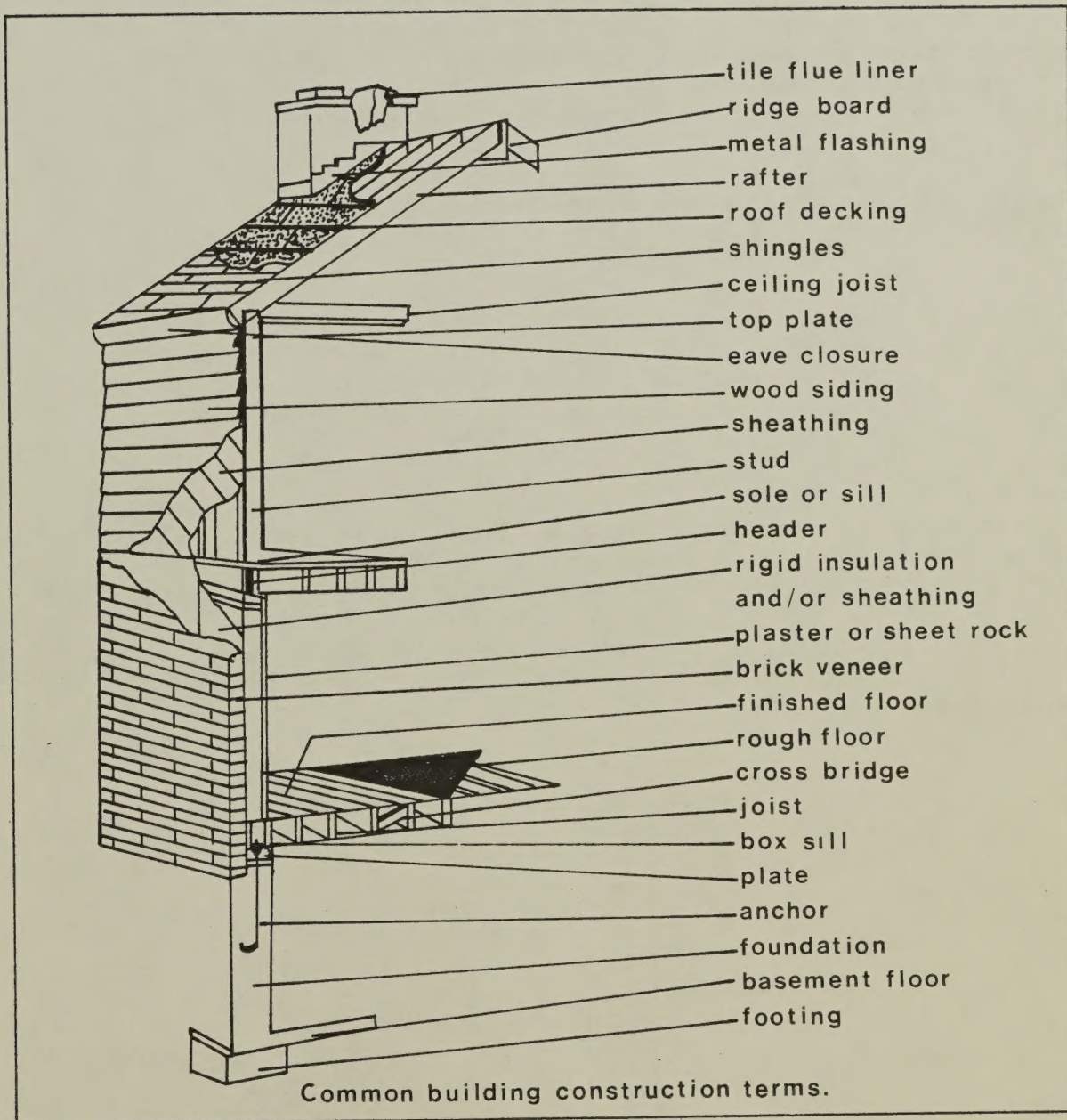
Modern type construction use top and bottom plates on the studs to create a section of wall before erecting. This method will prevent fire from travelling from floor to floor, but it can still travel the height of the partition or wall.

Roofs are usually built of wood supporting members called "RAFTERS" to which wood sheathing is fastened. On top of the sheathing is the roof cover materials, wood shingles, asphalt, paper, tar and gravel, metal, and slate.



Fire stops of short pieces of wood cut off the draft within walls to reduce the spread of fire and smoke. Without them, a small controlled fire might be extending unseen.

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3. TYPES OF DOORS

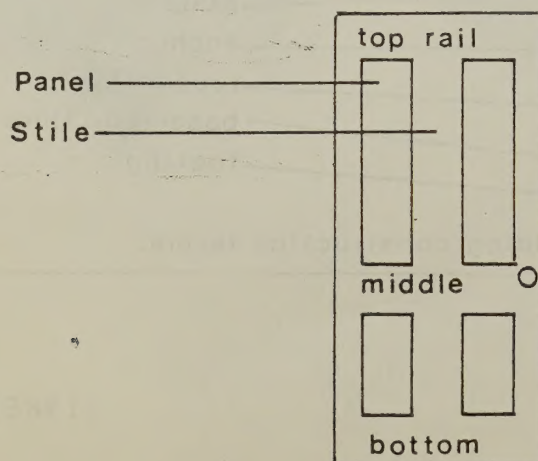
Doors of various types are used for entrance to buildings or areas within buildings. The construction features of some doors render them practically impossible to force, and entry may be more easily made by some other means. Doors may be classified as swinging, revolving, overhead, and sliding.

Regardless, of the class of door, firefighters should TRY THE DOOR TO MAKE SURE IT IS LOCKED before force is used.

If the door is locked, examine it to determine which way it swings and which method of forcible entry will prove most effective. Take note also to determine if illegal entry has been made prior to the arrival of the firefighters. This will aid in the investigation of the fire.

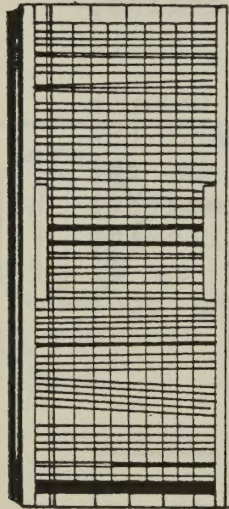
Three general kinds of wood swinging doors are: panel, slab, and ledge. Front doors in residences may be either panel or slab with glass panels in the upper area. Some glass panels are held in place with moulding which can be pried off. Residence doors usually open inwards; in this way they differ from outside doors in public buildings where the doors should open outward.

Panel Door - may be of several types, either cross or vertically panelled.

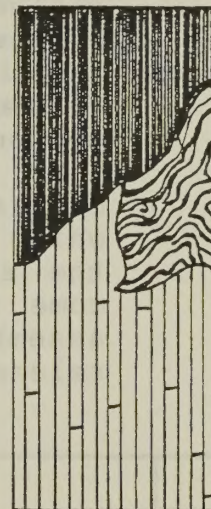
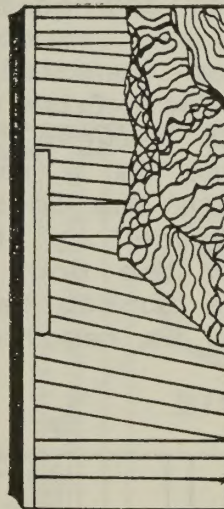


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Slab Doors - are very popular and may be constructed as either hollow-core or solid-core doors.

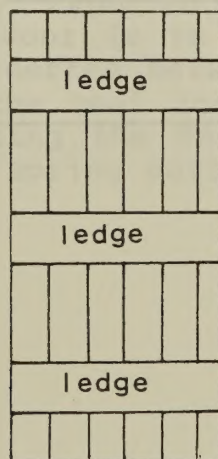


HOLLOW CORE



SOLID CORE

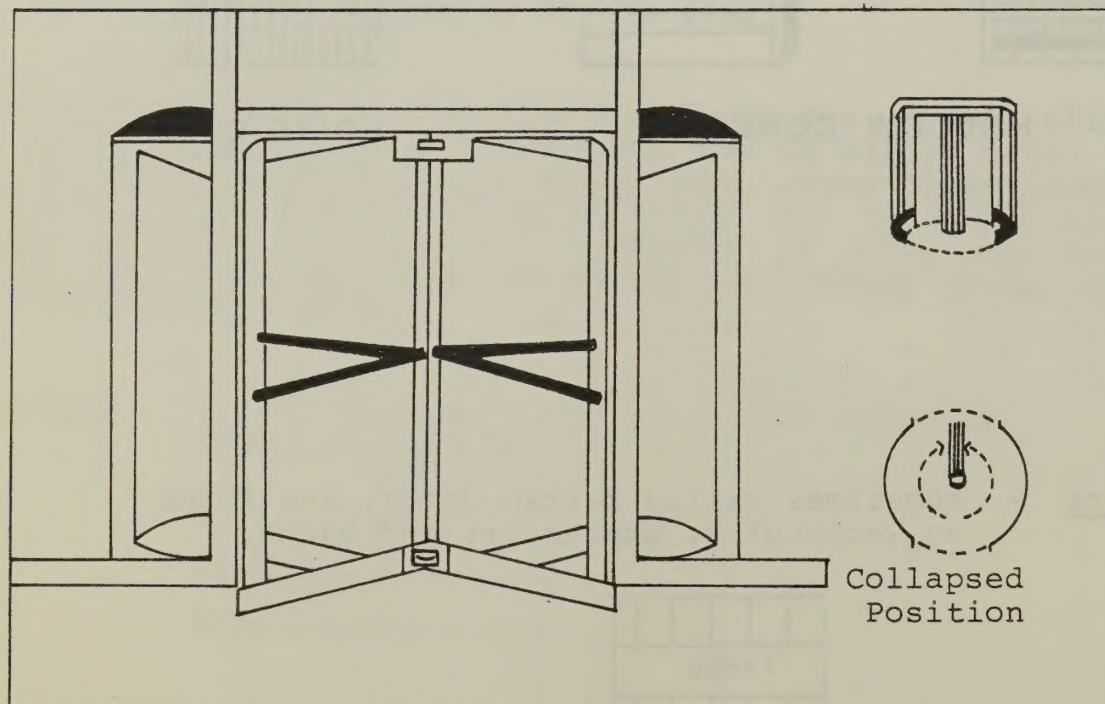
Ledge Doors - sometimes called batten doors, are found on warehouses, storerooms and barns.



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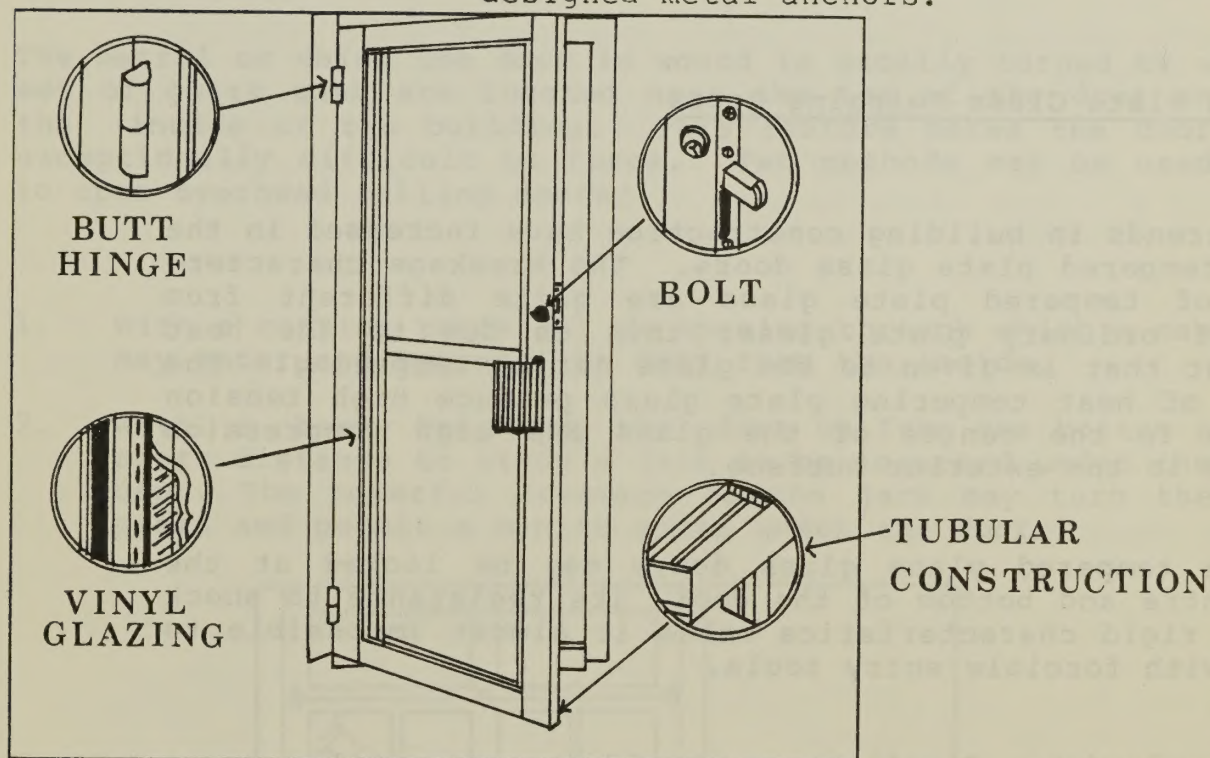
Revolving Doors - this type of door is usually found in hotels, department stores, public buildings. Various devices for collapsing revolving doors may be encountered and may include such devices as hooks, chains, pin lugs.

To remove the door from the axis when a person is caught between the door and the door jamb, there is a small lug in the centre seam where the doors come together which must be forced up and thus allowing the shaft which the door revolves on to come out of the bottom bearing. The door assembly can now be removed and the victim released.



(1986)

Metal Swinging Doors - may be classified as hollow-metal, metal covered. Tubular metal doors are generally difficult to force because of the manner which the door jams are constructed. This is more acute when the jamb is set in masonry. The jams for hollow metal doors, are hollow themselves and are fastened to the walls by specially designed metal anchors.



Forcing Doors That Open Away From The Firefighter

Doors that open away from an operator, present greater difficulties. If the door is in a stopped frame, the blade of the tool may be inserted between the stop and the jamb. The stop lifted and the tool inserted between the door and the jamb. By separating the door away from the jamb, the operator may lift the spring sufficiently to permit the bolt to pass the keeper.

(1986)

Double Swinging Doors

May be forced with most pry tools by prying the two doors apart at the lock to permit the bolt to pass the keeper. Sometimes a wood moulding is fastened to the edge of the door. Its purpose is to cover the crack between the doors when they are closed. In this event, the moulding must be removed before the blade or tool can be inserted.

Tempered Plate Glass Swinging Doors

Recent trends in building construction have increased in the use of tempered plate glass doors. The breakage characteristics of tempered plate glass are quite different from those of ordinary plate glass; this is due to the heat treatment that is given to the glass during tempering. The results of heat tempering plate glass produce high tension stresses in the centre of the glass and high compression stresses in the exterior surface.

Although tempered plate glass doors may be locked at the top, centre and bottom of the door, its resistance to shock and its rigid characteristics makes it almost impossible to spring with forcible entry tools.

Basic Conclusion: Firefighters should use every other means of entry.

A sharp pointed instrument of hardened steel is most effective in breaking tempered plate glass.

REMEMBER: PROTECT YOUR EYES FROM FLYING FRAGMENTS OF GLASS.

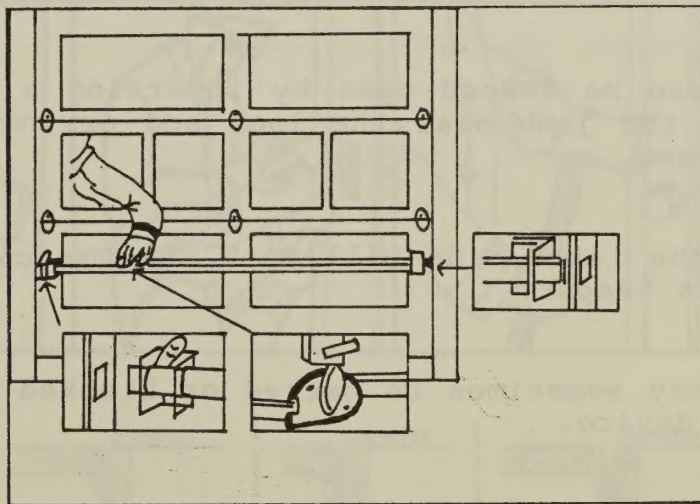
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Overhead Rolling Doors - are usually constructed from fabricated steel or aluminum or wood.

They are all similar in structural design and they may be mechanically, manually, or electrically operated.

The barrel on which the door is wound is usually turned by a set of gears that are located near the top of the door on the inside of the building. This feature makes the door exceptionally difficult to force. Two methods may be used to open overhead rolling doors:

1. With a cutting torch cut an opening through which a man may enter and operate the door from the inside.
2. With a heavy bar, pry the door up from the bottom a short distance to allow a jack to be inserted under the door. The powerful leverage of the jack may turn the gears and permit a man to enter under the door.



(1986)

SLIDING DOORS

From a forcible entry point of view, the sliding patio door presents a problem.

These units consist of heavy duty, full panel glass that is set into a metal or wood frame.

These glass panels are sometimes "thermopane" (two panels of glass with a vacuum space between them), and tempered which adds to their value.

Patio sliding doors usually glide past stationary glass panels instead of disappearing into a wall.

BREAKING THESE PANELS TO GAIN ENTRY IS NOT RECOMMENDED.

Sliding patio doors can be forced open by inserting a tool between the door and the jamb near the lock and prying the door away from the frame.

Lifting the door at the latch side will work in some cases. Let the latch pass its keeper.

Patio sliding doors may sometimes be barred or blocked by a metal rod or special device.

THIS FEATURE CAN BE SEEN FROM THE OUTSIDE AND IT PRACTICALLY ELIMINATES ANY POSSIBILITY OF FORCING.

(1986)

FIRE DOORS

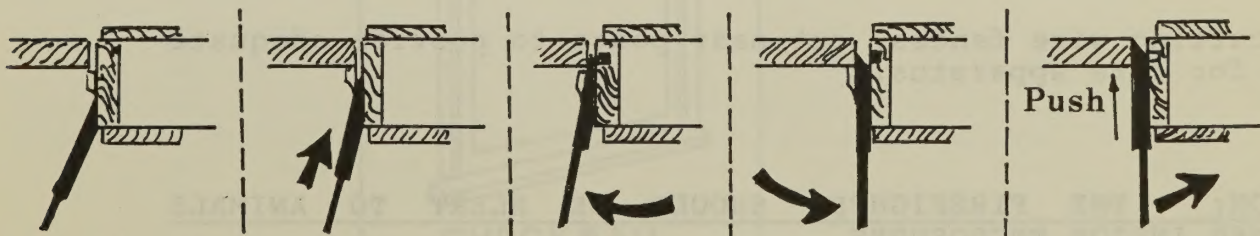
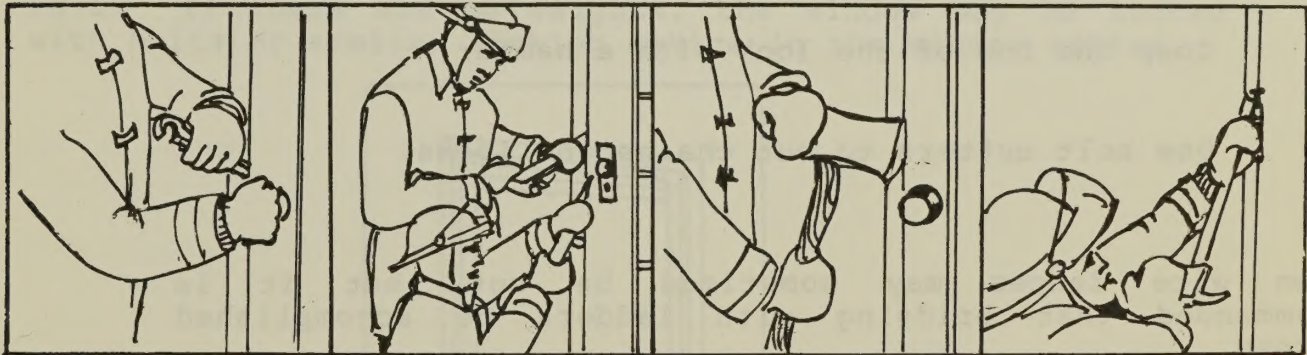
CAUTION: FIREFIGHTERS PASSING THROUGH AN OPENING PROTECTED BY A FIRE DOOR SHOULD BLOCK THE DOOR OPEN TO PREVENT ITS CLOSING AND TRAPPING THEM.

Fire doors have also been known to close behind firefighters and cut off the water supply in a hose line.

Stairwell type doors may lock so that entrance cannot be made without a key.

Opening Doors

There are many ways of forcing doors. However, some methods are very destructive. Some of the easier methods are shown in the following pictures.



(1986)

PROPERTY BARRIERS

Although property barriers are not doors, they are obstacles which firefighters normally encounter as they approach or enter into an area or premises such as fences.

Fences of wood, metal, masonry and woven wire often pose an entrance problem.

The gates on these fences are usually locked with padlock and hasps.

The following methods of forcible entry may be used:

- (1) Pull apart with a claw tool or cut with bolt cutter.
- (2) Twist hasp off using claw or other forcible entry tool.
- (3) Snap the bow of the lock with a hammer.
- (4) Use bolt cutters to cut chains and locks.

Woven wire fences may sometimes be cut, but it is recommended that bridging with ladders be accomplished instead.

When cutting wire fences, cut near posts to provide adequate space for fire apparatus.

CAUTION: THE FIREFIGHTER SHOULD BE ALERT TO ANIMALS
CONFINED INSIDE ENCLOSURES.

(1986)

4. TYPES OF WINDOWS

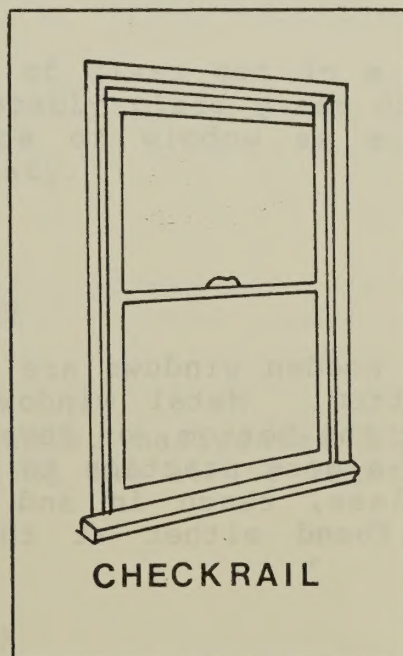
Residences: 1. Check Rail
 2. Casement
 3. Basement
 4. Picture
 5. Jalousie

Churches 6. Stained

Industrial 7. Factory Type

Check Rail Windows

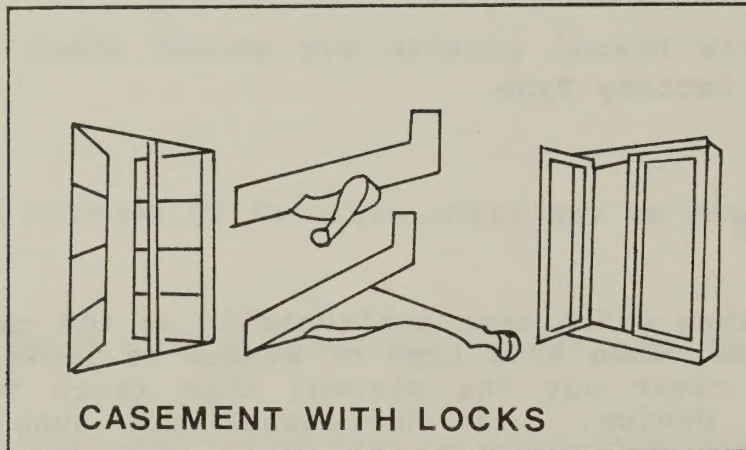
Consist of two sashes which meet horizontally at the centre. It is good practice, when this type of window is locked, to break the glass, clear out the pieces, then reach in and undo the locking device. If the sashes are hung with weights, they will be locked at the centre of the check rail. If there are no weights, the window may be locked with bolts or similar locking device in the window stiles.



(1986)

Casement Window

Sashes are hinged to the window jambs. To save damage to the sash and the locking device, it is a good practice to determine the position of the lock, break a pane near it, clear out the glass, reach in and undo the locking device.

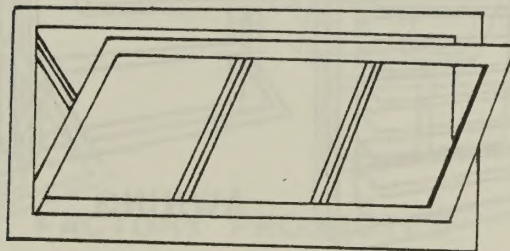


Basement Window - 2 Types

Wooden or metal construction. Wooden windows are hinged at the top and locked at the bottom. Metal windows may be hinged at the top and locked at the bottom, or reversed. To save damage to the sash, it is a good practice to break the centre pane, clear out the glass, reach in and undo the locking device. It will be found either at the top or bottom of the window.

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Basement Window



METAL

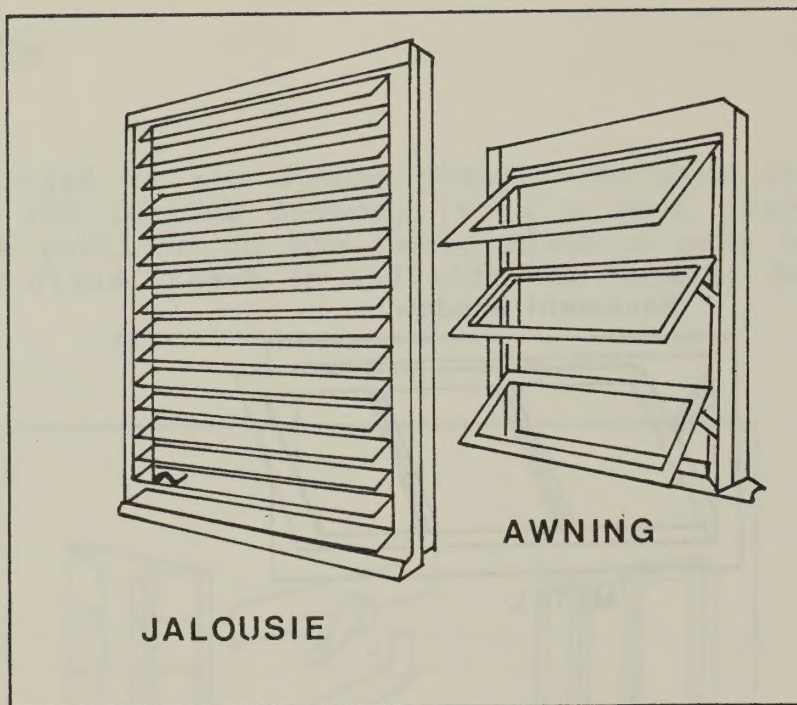
Picture Windows

Are a large pane of glass set in a stationary frame. The glass will be probably plate glass or insulating glass. Do not use this type of window as a point of entry unless absolutely necessary.

Jalousie Or Awning

Formed of adjustable, horizontal slats of wood, metal or glass for regulating the air or light coming through.

(1986)



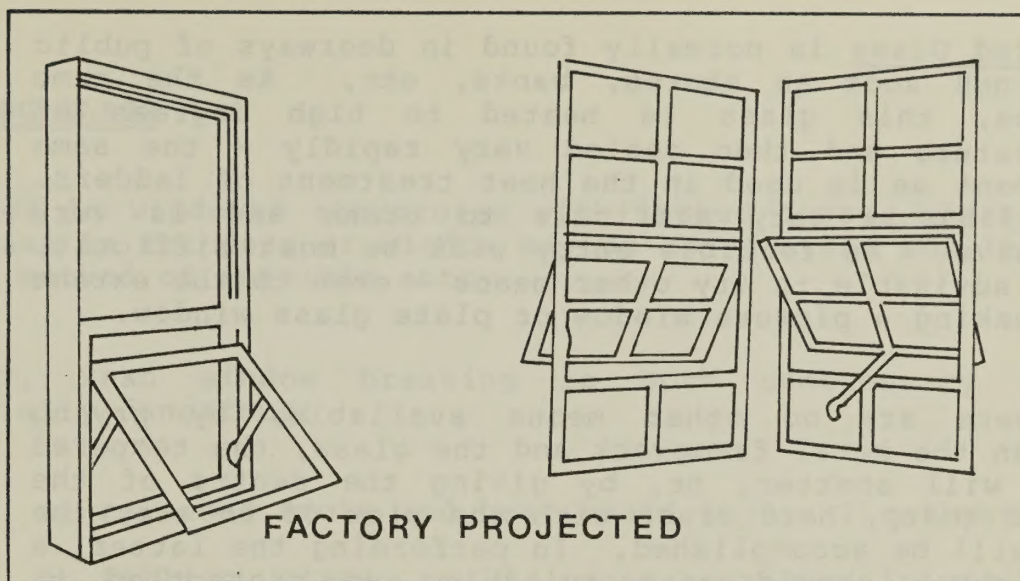
Stained Windows

Found in churches, are very expensive and care should be taken not to break these windows unless it is of the utmost importance. They are very costly and break very easily. They may break due to heat or when cold water is applied to them.

Factory Type Windows

Are commonly found in industrial buildings. Steel sash, glazed with wired glass set in a steel frame. The only part that may be opened is the pivot section in the centre which is used to ventilate the building. The simplest method of gaining entry is to break a pane of glass in the pivot section, near the locking bar device, reach in and lift the bar device.

(1986)



5. TYPES OF GLASS

1. Leaded glass should not be broken unless absolutely necessary, due to the high cost of replacing them. This type of window is usually found in churches and large estate homes.
2. Insulated glass is constructed of two or three separate panes of glass fastened together in one frame so that a vacuum or air-tight space remains between the panes. This type is also referred to as "Thermal" glass. Replacement of such windows is quite costly and should be avoided during Forcible Entry, if at all possible.

(1986)

3. Tempered Glass is normally found in doorways of public buildings such as stores, banks, etc. As the name implies, this glass is heated to high degrees of temperature and then cooled very rapidly - the same treatment as is used in the heat treatment of ladders. The glass is very difficult to break and is very expensive. As forcible entry will be most difficult, it is advisable to try other means - even to the extent of breaking a picture window or plate glass window.

If there are no other means available, by prying between the metal framework and the glass, the tempered glass will shatter, or, by giving the centre of the door a sharp, hard crack with the pick of an axe, the same will be accomplished. In performing the latter, a firefighter should wear suitable eye protection to protect against eye injury, or he should turn his face and head away from the door as the glass is being broken.

4. Wired Glass - is found in most factory windows or in doors and windows of storage areas in commercial outlets. One reason for its use is to discourage burglary. In order to remove this glass, we must first make a cut along the top of the pane and then cut down each side and then fold the glass in or out.
5. Plexiglass - a current trend in the construction industry is the use of Plexiglass and other thermoplastics in the place of glass windows.

"Lexan" is an example of one such polycarbonate which has seen wide application as a glass substitute for its ability to withstand abuse from vandalism or weather. A circular saw with a carbide tipped blade is most effective when entry must be made through Lexan.

(1986)

BREAKING GLASS

At fires in windowed structures with locked doors, breaking the glass in the door or window may be the fastest and least costly method of forcible entry.

However, rash window breaking is both unnecessary and potentially dangerous;

- a. released smoke and heat could injure firefighters
- b. falling glass could cause serious injury to personnel
- c. a delayed backdraft situation could develop if coordinated ventilation and hose line readiness did not accompany forcible entry techniques.

Ordinary window glass is relatively inexpensive, but more expensive tempered plate glass windows should be broken only as a final resort.

Consider the following points when breaking glass:

Try the window to verify it is locked.

Approach the glass from the windward side so that the wind will blow most of the smoke and heat away.

Keep hands above the point of impact to prevent broken glass from sliding down the tool handle.

Watch for signs of backdraft, such as smoke being sucked back inside the window.

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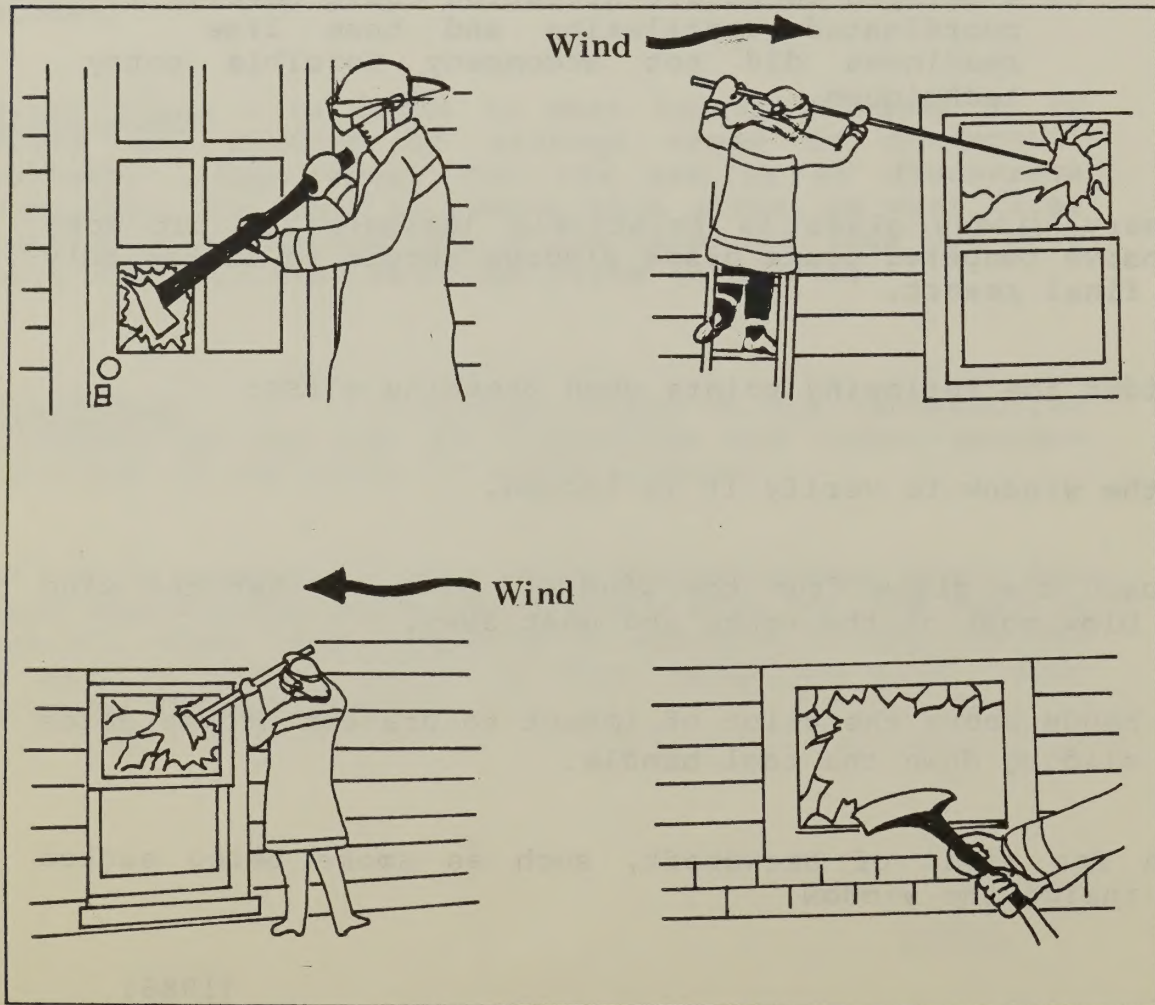
Have hose lines ready.

Clear all remaining jagged pieces of glass from the frame to prevent injury to personnel or hose lines.

Reach in and release the locking mechanism.

Special Considerations (Breaking Glass)

Breaking glass outward in highrise buildings creates hazards. Wear full protective clothing and eye protection. Also wear a life line. Remember the danger of falling glass to people below.



(1986)

6. TYPES OF ROOFS

Shingled - A shingled roof consists of small sections of material nailed to the sheeting and overlaid in a manner that will make the roof water-tight.

Built Up - A composition or built-up consists of asphalted paper fastened to a wooden sheeting. It will either consists of a single thickness of heavy material (cemented and lapped at the joints) or several thicknesses of light materials cemented together and fastened to the sheeting. This is covered with asphalt or asphalt with gravel. (commonly referred to as "TAR AND GRAVEL ROOF".)

General Procedures In Opening Shingled And Built-Up Roofs

1. Determine location to be opened.
2. Shingled - Remove shingles exposing sheeting. Built-up scrape away gravel and tar paper at the area to be opened.
3. Before cutting (A) Sound with an axe to determine location of the rafters and (B) Check the row of nails. Use partner K-12 (Wood Blade) if possible.
4. Make sure you are on the windward side, thus allowing smoke and gases to blow away from you. Save any boards cut for use in salvage operations.
5. Make the cut as close to the rafters as possible. Square or rectangular makes repairing easier.
6. If there is a ceiling below, open it by breaking the plaster, making it the same size to the one made in the roof.
7. A charged line should be ready at ALL times.

(1986)

Power Tools are Faster, Neater

Power tools so quickly open up a roof that they are much preferred over using an axe for that task. Although the circular saw requires more skill and care than an axe, especially when used on a roof, the resulting hole is not only fast-completed but is also much neater. This consideration takes on more importance when repairs must be made by the owner.

The general steps with a circular saw are similar to those with an axe. (A) Sound for the rafter locations. (B) Cut inside the far rafter. (C) Cut inside the near rafter. (D) Cut across the top and bottom to the two rafters. Don't cut the middle rafter. (E) Clear away the cut roofing material and punch through the ceiling below with a pike pole.

7. OPENING WALLS AND CEILINGS

1. Walls

The type of wall to be breached will indicate the tools and method to be used. For example, walls of stone, brick or block may be opened by:

1. Locate the desired position.
2. Remove bricks and blocks from centre until adequate size is obtained. (demolition hammer, etc.)

NOTE:

When opening a wall to accomplish fire fighting, charged lines must always be available. Care must be taken to prevent a BACK DRAFT CONDITION from being created.
(1986)

2. Ceilings

In opening ceilings of plaster and lath construction, the pike pole and plaster hook are ideal tools. Using a pike pole, the point is forced up into the ceiling. With a plaster hook, the point is forced into the ceiling by a chopping or swinging motion. In all instances after the tool is lodged, stand to one side away from the spot to be opened.

NOTE: The wearing of goggles prevents possible eye damage from falling plaster and dust particles.

Metal Lath covered ceilings (metal lath is suspended from rafters or ceilings joists by soft iron wire.) Sometimes in pulling down a portion of this type causes a whole section to collapse. The firefighter should be close to an exit to retreat from possible injury. (Point the hook of the tool down and away).

Bars Set In Masonry

Tools available for this operation of opening barred windows are oxy-acetylene cutting torch, Hurst tool, Bahco tool, Hydra-Spreader, or Partner K 12 Saw.

Bars may be freed with hand tools by following steps:

1. Strike the bar with a sledge hammer about 25 cm. above the sill. As the bar bends in, it will sometimes free itself.
2. Strike the sill with a sledge hammer opposite the end of the bar.

(1986)

3. Start the point of a cold chisel in the sill at the edge of the bar. Strike the head of the chisel with a sledge and crack the masonry to loosen the bar.

8. CAUTIONS AND PROCEDURES

When making a call for a lock-out, be sure to get proof of ownership before assisting the person or making a forcible entry.

As an added precaution, have a law enforcement officer present before taking any action at this type of call.

Some of the many safety cautions and procedures that apply to all forcible entry operations are listed as follows:

- * Always try a door or window before you pry.
- * Carry tools with the safety of yourself and others in mind.
- * Watch for explosive atmospheres.
- * When it is possible, block a door or window open after entrance to make a safe exit way.
- * Do not place tools where they will create a tripping hazard.
- * Stand to the side when breaking glass and remove all jagged pieces.
- * Block all overhead doors open (up position) after entrance.

(1986)

- * Watch for overhead obstructions and by-standers when swinging an axe and keep area clear whenever possible.
- * When opening walls and ceilings, watch for electrical wiring and pipes.
- * One large opening is usually better than several small openings.

CAUTION: A CHARGED HOSE LINE SHOULD ALWAYS BE AVAILABLE WHEN USING FORCIBLE ENTRY.

NOTE: FOR ADDITIONAL INFORMATION, REFER TO "I.F.S.T.A. MANUAL".

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CAUTION: A CHANGED WIRE LINE SHOULD ALWAYS BE KEPT
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UNDER THE ABOVE INFORMATION, PERIOD

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CHAPTER 10

SALVAGE AND OVERHAUL

1. INTRODUCTION

"Salvage is the saving of property!"

The use of salvage covers is a very important one, in many cases the damage done by water at a fire exceeds the actual fire loss and every man has seen how the quick and proper spreading of salvage covers has saved hundreds of dollars.

Salvage As Part Of The Fire Operation

1. Salvage operations offer one of the best methods of obtaining good public relations.
2. Speed and workmanship displayed during salvage operations convince the public that the men are well trained.
3. Good salvage procedure results in a minimum loss to the property owner. In time, this results in maintaining the best possible insurance rating.
4. To be efficient, salvage operations must be fast, they must be put into effect at the beginning of a fire.

Salvage Equipment

Salvage covers (tarpaulins)	Axe
Brooms	Trash Carriers
Mops	Hammers
Mop Wringer	Crow Bar
Scoop Shovels	Nails and Stapler
Pike Poles	Plastic Covering
Sawdust	Water Vac
Sprinkler Plugs	Portable Pumps
Plaster Hooks	

2. SALVAGE COVERS AND THEIR USE

Salvage covers or tarpaulins, as they are commonly called, may be used in various ways. Some of their uses include:

1. Covering furniture, machinery, fixtures, etc.
2. Making catch basins.
3. Making chutes.
4. Making basins to draft from.

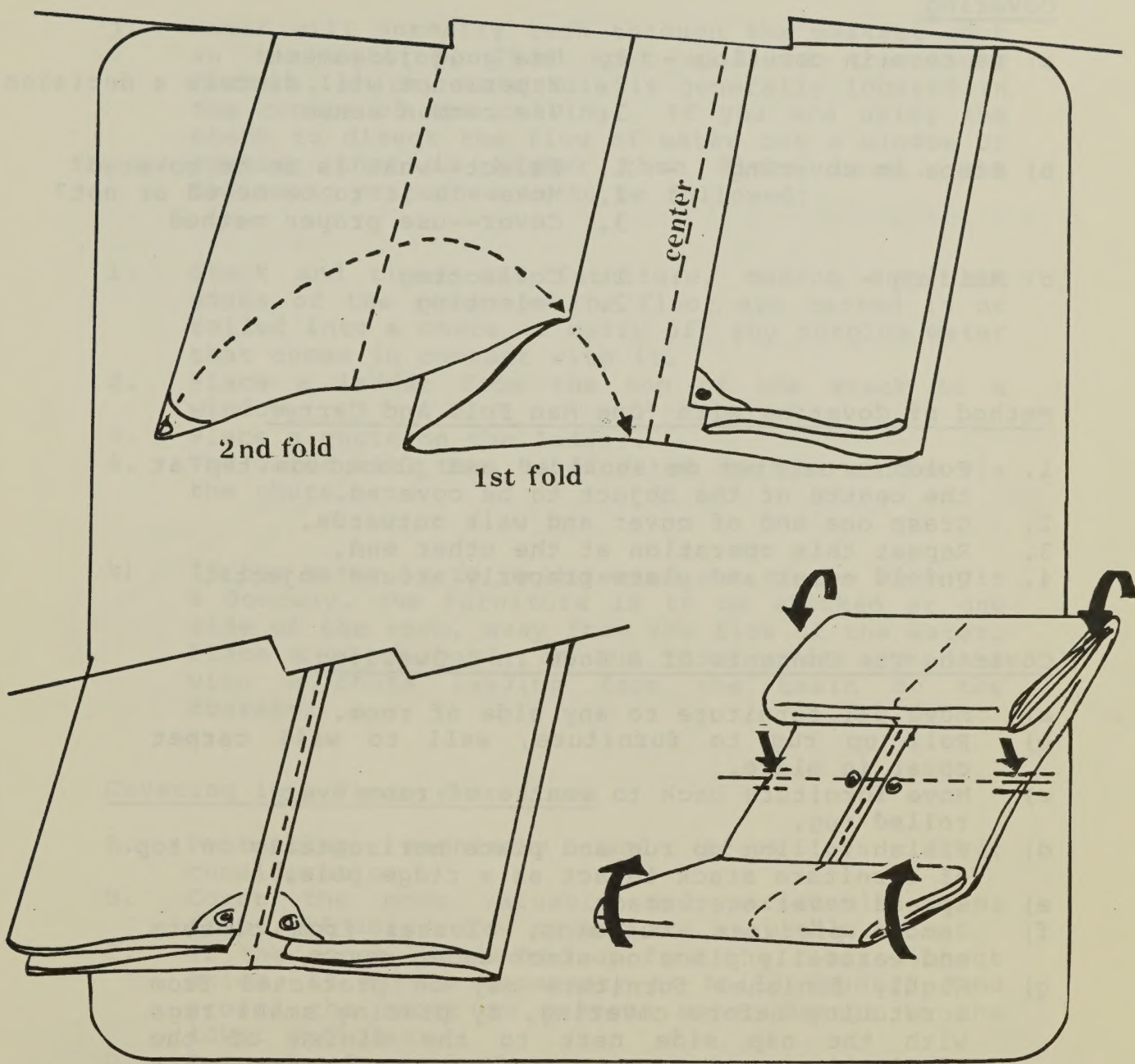
Method of Folding Covers

The fold adopted for use on the Hamilton Fire Department is the "One Man Fold and Carry." Although it takes two men to fold the cover, one man can easily cover stacked furniture, appliances, etc.

This is a lengthwise fold.

- a) Two men stretch out cover flat on floor.
- b) Each man takes his position at opposite ends facing each other.
- c) Divide the cover lengthwise in half by sight.
- d) Place the inner hand one-fourth the distance away from the centre fold.
- e) Place outer hand one-half the distance.
- f) Both men now fold the cover over with the outside hand, while the inner hand is breaking the cover at the one-fourth mark.
- g) Using the inside hand for breaking and the outside hand for folding, fold the remaining quarter of the cover to the centre line.
- h) The remaining half of the cover is folded in a likewise manner.
- i) Each man will fold his end to within 10 cm of the centre.
- j) Continue to fold to centre until two compact folds are made.
- k) Place one half on top of the other to complete the fold.

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Covering

- a) Factors in covering -
 - 1. Use good judgement
 - 2. Experience will dictate a decision
 - 3. Use common sense
- b) Steps in covering -
 - 1. Select--what is to be covered?
 - 2. Move--is it to be moved or not?
 - 3. Cover--use proper method
- c) Raiding -
 - 1. Collecting
 - 2. Selecting

Method of Covering With "One Man Fold And Carry"

- 1. Fold is carried on shoulder and placed on top at the centre of the object to be covered.
- 2. Grasp one end of cover and walk outwards.
- 3. Repeat this operation at the other end.
- 4. Unfold cover and place properly around objects.

Covering The Contents Of A Room In A Dwelling

- a) Move all furniture to any side of room.
- b) Roll up rug to furniture, wall to wall carpet cover in place.
- c) Move furniture back to centre of room over rolled rug.
- d) Finish rolling up rug and place horizontally on top of furniture stack to act as a ridge pole.
- e) Spread cover over stack.
- f) Remove pictures, curtains, clothes from closets and carefully place on stack under cover.
- g) Highly finished furniture may be protected from scratching before covering, by placing small rugs with the nap side next to the finish of the furniture. Blankets, drapes or other soft materials may be used for the same purpose.
- h) If the rug is already wet, it may be rolled around the stack and then covered.
- i) Stack chairs so that sharp edges or protruding legs will not tear the covers.

(1986)

- j) Water will normally leak through the weakest spot in the ceiling. This spot will be the light fixture, which, as a rule is generally located in the centre of the ceiling. If you are using the stack to direct the flow of water out a window or opening that is higher than floor level, the following procedure is to be followed:
1. Stack and cover the furniture, making sure the edges of the cover on the floor are tucked in or rolled into a chute to carry off any surplus water that comes in contact with it.
 2. Place a ladder from the top of the stack to a window.
 3. Place a chute on the ladder.
 4. The water will then be directed out the window via the chute.
- k) If the water is to be directed out of the room via a doorway, the furniture is to be stacked at one side of the room, away from the flow of the water. Place a catch basin on the floor under the leak with a chute leading from the basin to the doorway.

Covering in a Factory or Store

- A. Protecting machinery and stock is first consideration.
- B. Cover the most valuable and perishable items first, if only a few covers are available.
- C. If the stock is stacked up from the floor without skids, it may be necessary to build sawdust dams around the stock to prevent water damage to the lower articles.
- D. Removal of stock from a room is usually a last resort and is governed by available manpower.
- E. Covering Shelves
Shelves built away from walls (detached).
 1. When covering, care should be taken to make sure that the shelves are not pushed over.
 2. If several covers are stretched over, the lap must be 50 cm so that the water will run off and not into the covers.

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Shelves built onto walls (attached):

1. Stretch covers by fastening with tarp hooks through grommets to shelves or wall.
2. Wood lath may be used as a cleat.

Shelves built to defy adequate protection:

1. Remove contents and re-stack in safe area.

3. CATCH BASINS AND CHUTES

Uses

1. To collect small amounts of water.
2. Provide pump reservoir.

Method of Making a Small Catch Basin - 2 Men

1. Cover is spread flat.
2. Both men grasp adjacent corners on long side.
3. Both men roll simultaneously at least three turns.
4. Move to opposite long side and roll similarly.
5. Both men move to one short side.
6. Fold rolled edge at corner up and in, to form a 45° edge on each corner.
7. Roll the short edge simultaneously for at least three turns.
8. Repeat on opposite side.
9. Make sure corners are tucked in.

Large Catch Basin - 2 Men

1. Use a roof ladder and short extension ladder (divide extension ladder to form 2 separate ladders).
2. Join the 3 ladders to form a triangle.
3. Secure the ladders together with hose straps.
4. Two men stretch the cover over top of the hollow triangle.
5. One man climbs over the edge, stepping in the centre of the cover, causing it to move to the floor.
6. Man in the centre "bags" or tucks the cover, forming a basin.

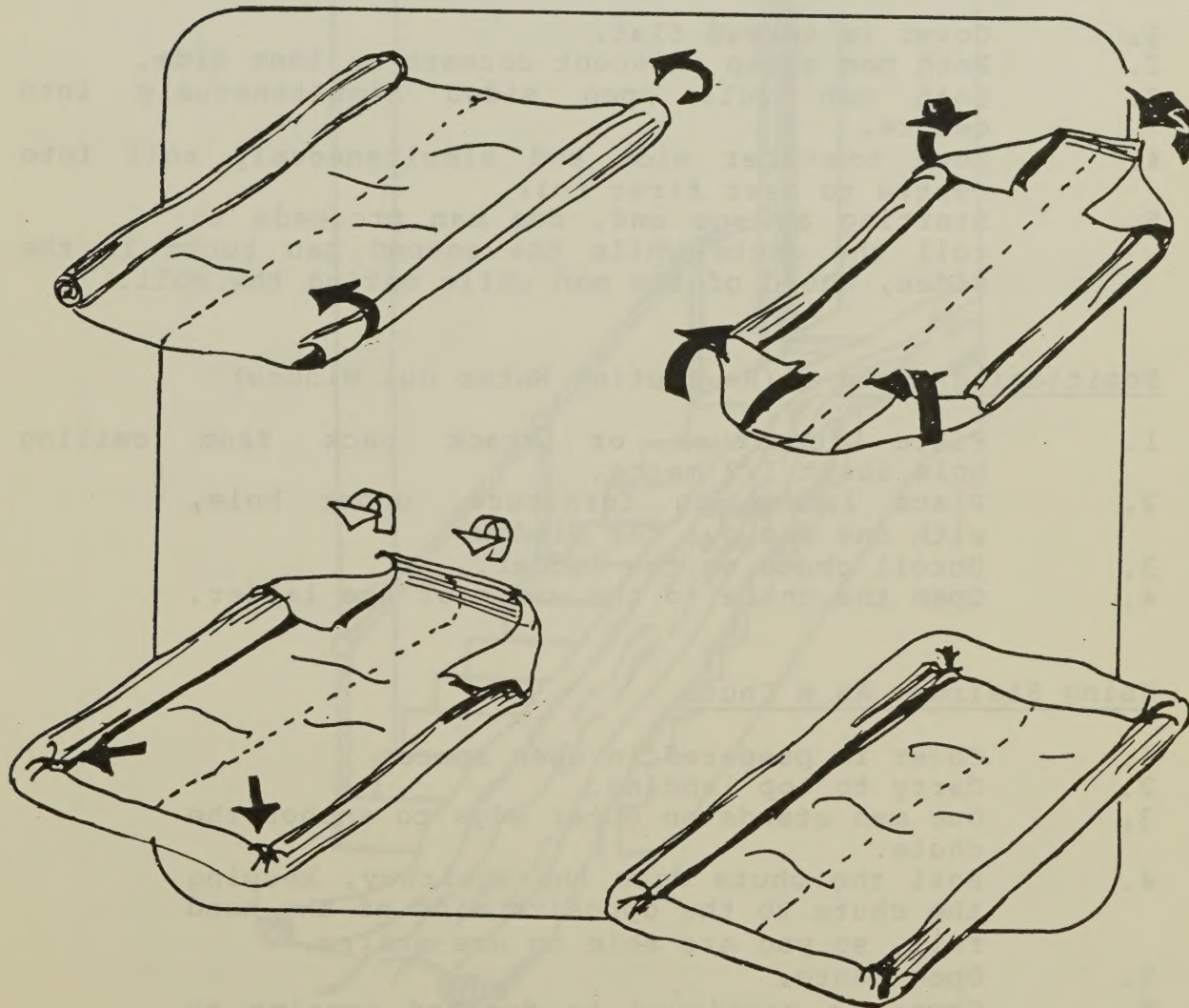
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7. Outside man smooths edges.
8. As an alternative to using ladders, any suitable frame work may be used, such as chairs, etc.

Rolled Catch Basin - 1 Man

Start at any corner and roll cover in a circular motion until the basin is formed.

Small Catch Basin - 2 man



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CHUTES

Use of Chutes

1. To carry water from catch basins to the outside of a building.
2. Using stairway as a waterway, by placing chute on the stairway (place chute opposite hand rail).

MAKING CHUTES

Rolled Chute - 2 Men

1. Cover is spread flat.
2. Both men grasp adjacent corners on long side.
3. Both men roll open sides simultaneously into centre.
4. Move to other side and simultaneously roll into centre to meet first roll.
5. Starting at one end, one man proceeds to roll the chute while the second man tucks in the sides, ahead of the man while making the roll.

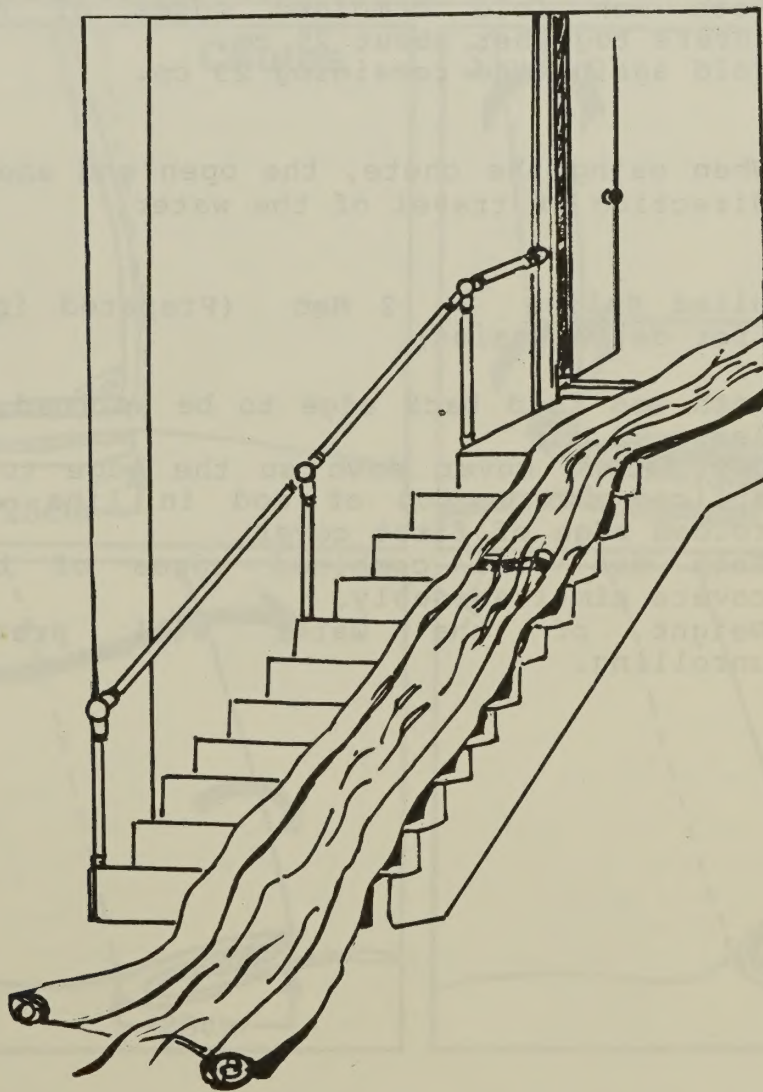
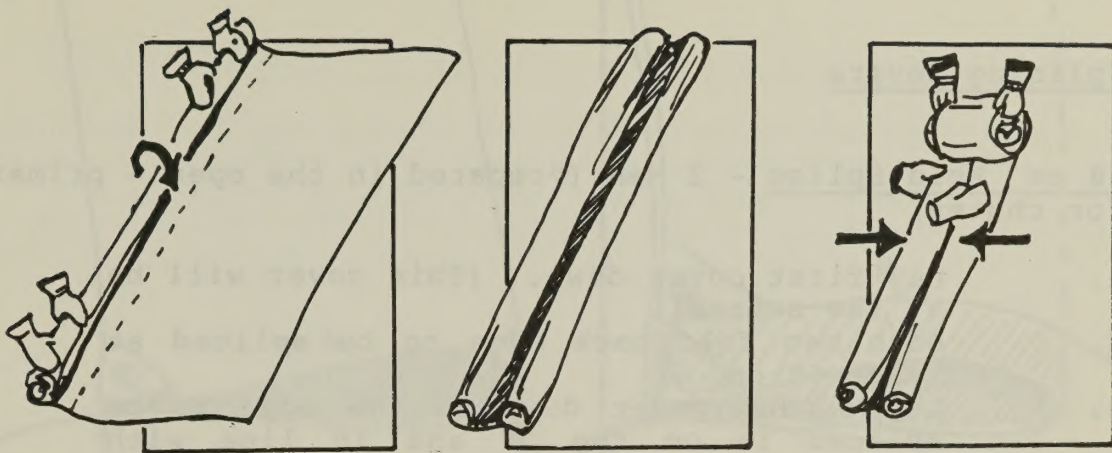
Positioning Chute - (Re-Routing Water Out Window)

1. Place furniture or stack back from ceiling hole about 1/2 metre.
2. Place ladder on furniture, under hole, with one end out the window.
3. Unroll chute on the ladder.
4. Open the chute to the width of the ladder.

Using Stairway As A Chute

1. Cover is prepared in open space.
2. Carry to top landing.
3. One man stands on outer edge to anchor the chute.
4. Roll the chute down the stairway, keeping the chute to the opposite side of the hand rail, so you are able to use stairs.
5. Open chute.
6. Chute is continued to desired opening by splicing chutes together as necessary.

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Splicing Covers

50 cm Fold Splice - 2 Men (Prepared in the open - primarily for chutes)

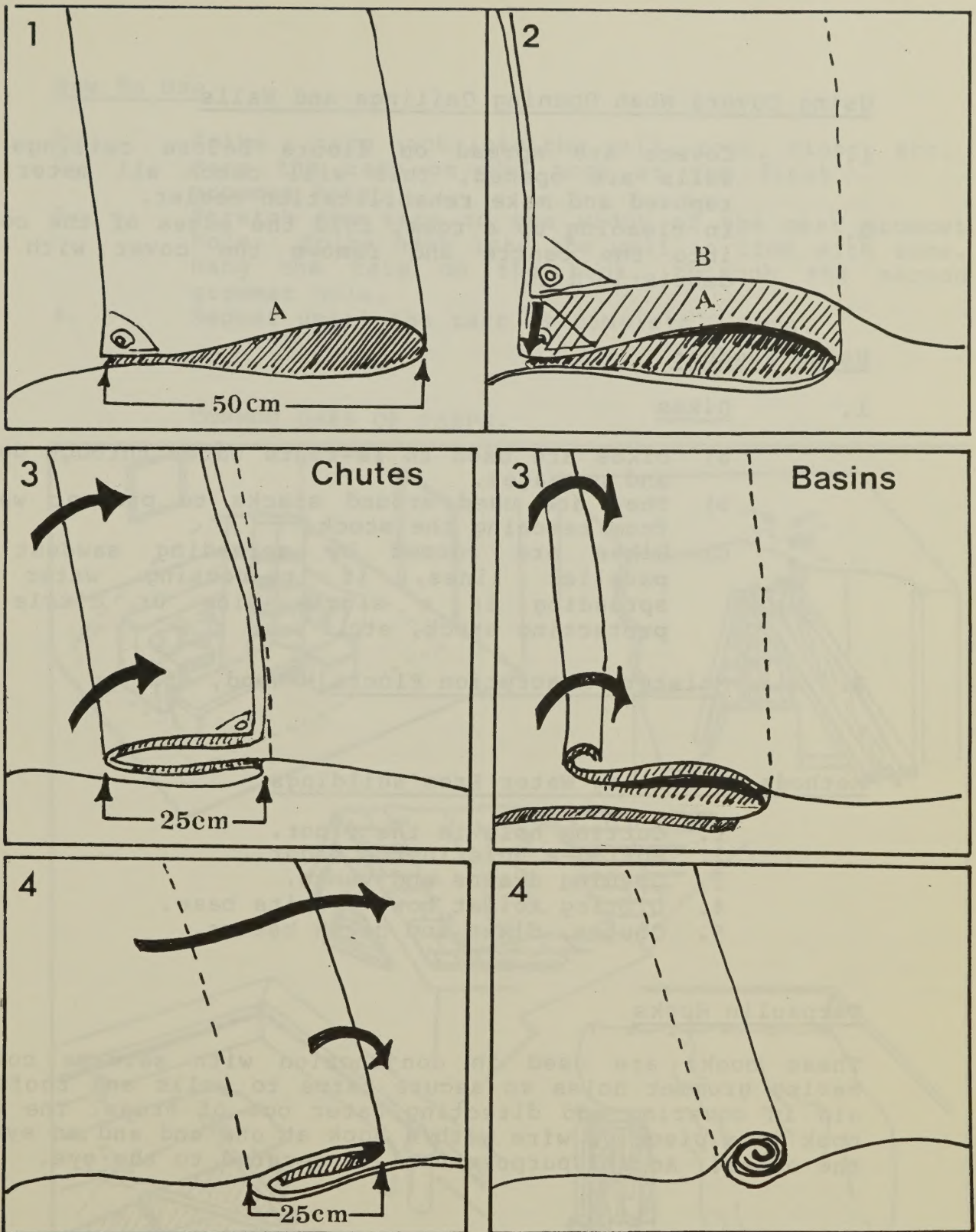
1. Lay first cover down. (This cover will be at the source).
2. Both men fold back edge to be spliced at least 50 cm.
3. Lay second cover down so the edge to be spliced is on top of and in line with folded edge of first cover.
4. Both men fold combined edges of both covers together about 25 cm.
5. Fold again, the remaining 25 cm.

NOTE: When using the chute, the open end should face the direction of travel of the water.

50 cm Rolled Splice - 2 Men (Prepared in the open - primarily for catch basins)

1. Both men fold back edge to be spliced, at least 50 cm.
2. Lay second cover down so the edge to be spliced is on top of and in line with folded edge of first cover.
3. Both men roll combined edges of both covers simultaneously.
4. Weight of the water will prevent unrolling.

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Using Covers When Opening Ceilings and Walls

1. Covers are spread on floors before ceilings or walls are opened. This will catch all materials removed and make rehabilitation easier.
2. In cleaning up a room, fold the edges of the cover into the centre and remove the cover with the debris in it.

Using Sawdust

1. Dikes

- a) Dikes are used to re-route water through doors and passages.
- b) They are used around stacks to prevent water from reaching the stock.
- c) Dikes are formed by spreading sawdust in parallel lines, if re-routing water or spreading in a single line or circle if protecting stock, etc.

2. Moisture Absorption Floors - Wood, etc.

Methods of Routing Water From Buildings

1. Cutting hole in the floor.
2. Boring a hole in the floor.
3. Opening drains and vents.
4. Lifting toilet bowl off its base.
5. Chutes, dikes and catch basins.

Tarpaulin Hooks

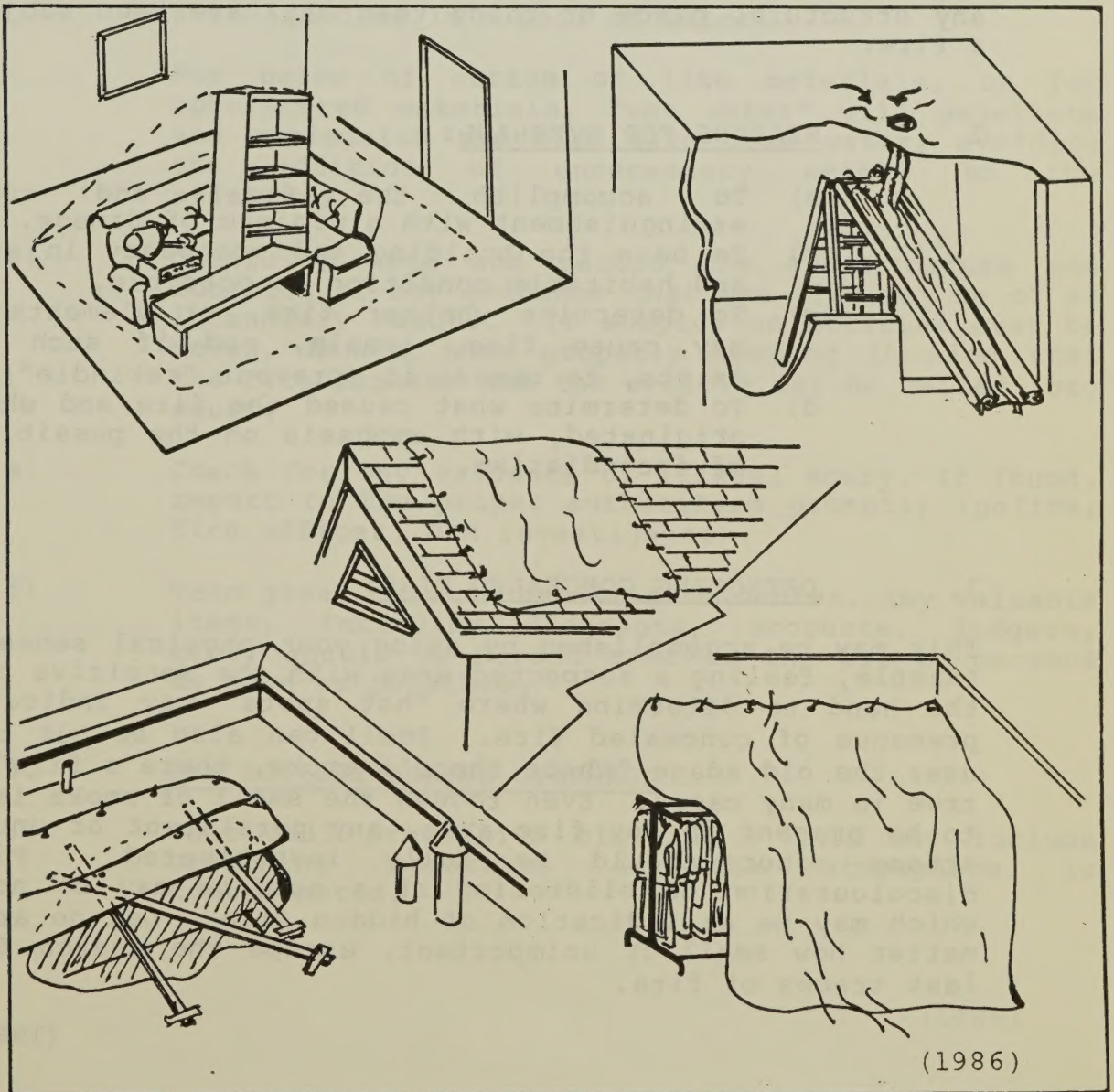
These hooks are used in conjunction with salvage covers having grommet holes to secure tarps to walls and roofs to aid in covering and directing water out of areas. The tarp hook is a piece of wire with a hook at one end and an eye at the other. An all purpose nail is secured to the eye.

(1986)

How To Use

1. Spike a tarp hook into the wall, roof, floor, etc.
2. Hang the tarp on the hook at the first grommet hole.
3. Stretch the tarp to the width of the next grommet hole. Spike hook into the wall in line with same. Hang the tarp on the hook, through the second grommet hole.
4. Repeat until the tarp is completely hung.

COMMON USES OF TARPS.



Trash Carriers

These are small covers, usually 2 m X 2 m, with hand holds, and are made from discarded salvage covers. They are useful in carrying debris from a building.

4. OVERHAUL

1. INTRODUCTION:

Overhaul can be defined as the practice of searching for any sparks, embers, or fire that may remain in a building, or in any structure, place or thing that may have been subject to a fire.

2. REASONS FOR OVERHAUL:

- a) To accomplish the final and complete extinguishment with a minimum of damage.
- b) To have the building and occupancy in as safe and habitable condition as possible.
- c) To determine whether fire, or elements which may cause fire, remain, and if such threat exists, to remove it (prevent "rekindle").
- d) To determine what caused the fire and where it originated, with emphasis on the possibilities of incendiarism.

3. DETECTING CONCEALED FIRE:

This may be accomplished by using your physical senses, for example, feeling a suspected area with the sensitive part of the hand to determine where "hot spots" may indicate the presence of concealed fire. Smell can also be put to good use; the old adage "Where there's smoke, there's fire" holds true in many cases. Even though the smell of smoke is bound to be present in any fire area, any persistent or unusually strong odour should be fully investigated. Finally, discolouration or blistering of a surface may be noticed, which may be an indication of hidden fire. Let no area, no matter how small or unimportant, escape the search for the last traces of fire.

(1986)

4. GENERAL PROCEDURE

- a) Use only enough men to do the job properly. Using more men than necessary will result in an inefficient operation and may add unnecessarily to the weight load a weakened structure must support. The teams should be commanded by an officer.
- b) Start at the top and work down. Follow a systematic pattern. Articles which have been checked should be moved close to supported walls to reduce the weight on floors.
- c) Wet down all suspicious articles. If possible, soak articles in a pail of water.

For bales of cotton or like materials, or for upholstered materials, "wet water" will penetrate and extinguish the fire with less water, avoiding the addition of unnecessary weight to the structure.

- d) Carefully note and record the exact nature and location of any evidence that the fire may be of an incendiary nature. If suspicious articles must be moved, handle them properly keeping in mind that the fire fighter and the article may be called into court.
- e) Check for any evidence of illegal entry. If found, report to the proper authorities promptly (police, fire officer, OFM investigator).
- f) Take great care in handling valuables. Any valuable items, including documents, accounts, ledgers, etc., should be handed over to the proper persons as soon as possible.

5. PRECAUTIONS DURING OVERHAUL

- a) Wear full protective clothing - this may include breathing apparatus if the atmosphere is contaminated.

(1986)

- b) If removing or handling chemicals, take the necessary precautions. Remember the possibility of a chemical reaction.
- c) Spell men off regularly, if possible.
- d) Wash all tools and hands thoroughly when finished. They are most likely contaminated.

6. BE THOROUGH

The fire department cannot be held responsible for any damage caused by the fire but it is certainly responsible for any damage which occurs as a result of its members' actions, including "rekindle". BE SURE IT IS OUT.

5. REHABILITATION AFTER SALVAGE AND OVERHAUL

Rehabilitation is the returning of a room, store or building, etc. to the condition or near condition of what it was, before the fire occurred. All debris is removed along with anything of complete loss. Salvageable material is stacked and not completely removed.

Rehabilitation Operation

1. Cleanup

a) Water Removal

- 1. Pump or siphon in basement or depressed space to remove water.
- 2. Mop up residue.
- 3. Spread sawdust on wooden floors.
- 4. Wet salvageable material is placed in a bathtub or similar place to drain.

b) Return Stock To Original Position

- 1. Unharmed rugs are set in dry location where they will be safe.
- 2. Notify owner if rugs are wet.
- 3. Furniture or stock, etc., to be placed in original locations when possible.

(1986)

c) Ventilation

1. Ventilate to dry out premises and relieve smoke conditions.
2. In freezing weather, exercise judgement in ventilating wet areas.

2. Closing Up

a) Windows and Walls (close the openings with plastic covering, always remove loose glass).

1. One man holds open the plastic edge, parallel with the top of the frame on the outside (or inside) of the openings.
2. Second man places strip of wood lath and secures over the plastic with nail driven into the wood or caulking.
3. Drive nail in halfway.
4. Secure sides similarly.
5. Cut plastic to size along bottom and secure with lath.

NOTE: Metal frames - use duct tape in roofing kit.
Wood frames - staple gun can be used in place of nails.

b) Roofs - small openings.

1. Cut plastic oversize.
2. Manufacture a cross framework of debris over the hole to support the plastic.
3. Place the cover and secure it with wood lath and nails driven in halfway.

Roofs - large openings (conventional method)

1. Area of opening too large for plastic covering.
2. Roof laddered and customary precautions are taken on roof.
3. Framework may be manufactured in some cases.

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4. Stretch salvage cover over framework.
5. Top edge is lapped under shingles and secured with wood lath and nails. Drive nails through grommet holes only.
6. Stretch over entire opening and secure both edges with lath.
7. In some cases, wood lath may not be available, the salvage cover may be secured by using tarp hooks and stretching the cover taut.

c) Skylights

1. Stretch cover over open skylight.
2. Fold corners at corners as in wrapping a package.
3. Tie rope around bottom edge of entire frame of skylight and knot.

d) Floors

1. Small holes should be clearly marked.
2. Large holes should be barricaded.

6. FINAL ACTION

1. Proper Hamilton Fire Department forms are filled out and signed by owner or representatives. Example: sprinkler, standpipe, alarm systems, electric, gas, and water services, etc.
2. Advise owner of any unsafe conditions in the building.
3. Secure building and ask for police guard if required.
4. Placard building if required (O.F.M. placards).
5. If salvage covers left at scene, inform the owner that they are to make alternate arrangements within 48 hours.

7. CARE OF SALVAGE COVERS

Salvage covers are subject to a lot of hard wear and rough treatment. To assure efficient use, they must be properly cared for and maintained. It is important that any maintenance be carried out as soon as possible, in order to get this necessary equipment back in service.

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Care While In Use

1. Salvage covers should never be thrown from roofs, windows or other openings above ground level.
2. When removing covers from stock or machinery, care must be exercised in pulling over sharp projections to prevent tearing.
3. It is bad practice to walk on salvage covers unnecessarily. Small sharp pieces of debris under the cover may cut through when stepped on.

Care After Use

1. Immediately after use, covers should be washed and hung to dry. Clear, cold water and a broom, is usually all that is necessary. Mild soap may be used where there is excess dirt, oil, or grease, etc.
2. When washing covers, be sure the area underneath the cover is free from stones, cinders, etc., that might damage the cover as it is walked on during washing operations.
3. After the covers are dry, they should be examined for holes. Torn covers are to be sent to the storeroom immediately for repair.
4. Where covers do not get used regularly, it is necessary to refold them on the first Sunday of every month.

NOTE: FOR ADDITIONAL INFORMATION, REFER TO I.F.S.T.A.
MANUAL

(1986)

CHAPTER 11

PART 1

FIRE STREAMS

FIRE DEPARTMENT HYDRAULICS SECTION 1

1. INTRODUCTION

The dictionary defines HYDRAULICS as - water conveyed through pipes or other channels, or the science of conveyance of liquids through pipes for motive power.

In the fire service, we define HYDRAULICS as the transfer of water from a source of supply, i.e., hydrant, pond, river, etc. through hose lines to the site of the fire.

The fire fighter, particularly the pump operator, must understand hydraulics in order to:

- (a) develop and maintain good hose streams,
- (b) know safe working nozzle pressures,
- (c) know the capacity of the pump under varying conditions,
- (d) recognize when discharge is nearing the available supply of water,
- (e) determine the volume of water which is being applied to the fire,
- (f) determine the mass of water which is being put into the building,
- (g) do a more efficient pumping job.

2. STANDARD TERMINOLOGY:

Pascal is a unit used to measure pressure. Since it is a very small unit of pressure, the fire fighter will usually use kilo Pascals (1,000 Pascals) when referring to pressure. This is usually denoted as kPa.

(1986)

Discharge or Volume is a measure of the quantity or volume of water being delivered through hose lines or the orifice in a nozzle. It is expressed in Litres per minute or L/min.

Pressure is the energy necessary to do the work. Pressure is always expressed in Pascals (Pa) or kilo Pascals (kPa).

Friction Loss is pressure lost in moving water through a system. It is usually expressed in kPa.

Velocity is the rate of speed at which water moves, and is usually expressed in metres per second (m/sec).

Reaction is the back pressure or pull-back, developed when water is discharged through a nozzle. It is measured in Newtons (N).

Head or Elevation the measure of the height to which water is raised vertically. It is usually expressed in metres but may be converted to "head pressure" and expressed as kPa.

Common abbreviations used in hydraulics include:

kPa KiloPascal

L Litres

m metre

mm millimetre

L/min. Litres per minute

F.L. Friction Loss (unit kPa)

N.P. Nozzle Pressure (unit kPa)

P.P. Pump Pressure (unit kPa)

A² Number represented by A multiplied by itself

N Newtons

F.G.F. Fire Ground Figure

D Diameter

Q L/min divided by 100 or $\frac{Lmin}{100}$

√ Square root

(1986)

The Basic Prefixes

<u>POWER</u>	<u>POWER</u>	<u>SYMBOL</u>	<u>EXAMPLE</u>
kilo	1,000	k	1 kilometer = 1,000 meters
hecto	100	h	1 hectometer = 100 meters
deca	10	da	1 decameter = 10 meters
deci	.1	d	1 decimeter = 1/10 of a meter
centi	.01	c	1 centimeter = 1/100 of a meter
milli	.001	mm	1 millimeter = 1/1000 of a meter

3. FACTS ABOUT WATER

- Water is the commonest extinguisher agent.
- Water is practically incompressible (210,000 kPa to compress by 1%).
- Water is constant in volume - a given mass of water will always occupy the same space, and a given volume will always have the same mass.
- One cubic decimetre of water has a mass of one kilogram.
- One cubic decimetre of water is one Litre.
- One litre of water has a mass of 1 kilogram.
- A pressure of 1 kPa will raise a column of water 10 cm (0.1 m)
- Water can be moved by mechanical means.
- Water seeks its own level.
- Water freezes at 0°C and boils at 100°C at sea level.

(1986)

4. HOW WATER IS DELIVERED TO THE PUMP

Water is delivered to a pump either from a pressurized source, by draft or by gravity.

Positive pressure on water may be generated by the force of gravity or by mechanical means. Atmospheric pressure on the other hand provides the force which delivers water to the suction side of the pump during drafting operations.

- (a) Gravity: Water has density and is subject to the law of gravity. Thus, the force of gravity on one litre of water is one kilogram, which is its mass.

In the process of pumping water, the force of gravity on mass of water is referred to as head pressure, that is, a column of water 10 cm (0.1 m) high exerts a pressure upon the bottom of the container of 1 kPa.

It is obvious that changing the height of the column of water will change the pressure upon the bottom proportionately.

Thus, a column of water 1 metre high will exert a pressure of 10 kPa.

Therefore, a column 30 m high would exert a pressure of 300 kPa.

Water in a container exerts pressure in every direction, but it is the downward pressure with which we are here concerned. In the case of the elevated water tank, the pressure exerted is that created by gravity. The mass of the water exerts a pressure upon the container in all directions in proportion to the height of the water column. This we call head pressure and in a water system, if the tank is high enough the pressure will be sufficient to provide a desirable flow of water.

The same force of gravity that afforded pressure for forcing water to the hydrant and beyond, due to an elevated reservoir, works against the pump operator if he is to force the stream to a higher level than the pump.

(1986)

Each metre of elevation above the pump outlet offers a head pressure of 10 kPa and this added pressure must be supplied by the pump.

- (b) Mechanical: Positive pressure may be produced by mechanical means, e.g., fire department pumper or water works pumping stations pumping directly into the grid system of watermains.
- (c) Drafting: Not always can a pump operator secure his supply of water from a hydrant where the water is under pressure. Many times he must draft from a supply of water which is subjected only to atmospheric pressure.

The earth's atmosphere exerts a pressure of 101.4 kPa upon the surface of water at sea level.

As we draw off the air within the pump chamber and suction hose, the pressure within this space will be lowered, providing the pump is air tight. The pressure within the pump falls below the atmospheric pressure which is pushing down on the surface of the water from which the pump is drafting. The atmospheric pressure on the surface of the water forces the water up the suction hose 10 cm for each kPa of pressure difference and, if the differential is great enough, into the pump where it is put in motion by the action of the pump.

There is a limit to the vertical distance we can draft. If a perfect vacuum could be produced it would be possible to lift water 101.43 (atmospheric pressure at sea level) $\times$ 0.1 m (the height to which 1 kPa pressure will raise water vertically) for a total of 10.143 m or approximately 10 m.

The height of lift decreases with altitude since atmospheric pressure is less than at sea level. The common practice is to use two-thirds of the theoretical height (or 6.66 m at sea level) for the practical limit of draft. This height decreases with altitude about 0.3 m for each 300 m of altitude.

(1986)

Let us remember that applied pressure, be it gravity, atmospheric or mechanical, or a combination of the three, is the primary factor in pumping water to produce fire streams.

5. TYPES OF PRESSURES:

There are three types of pressure which must be considered in fire department hydraulics:

(a) Static Pressure

Means without motion or standing still. Thus, water in a fire hydrant is under static pressure as long as the water is not flowing. No hindering forces are affecting it as it is not moving, and whether the pressure be produced by gravity or by pump, the line is still under static pressure.

(b) Flow Pressure

Cannot be as great as static pressure because when the stream is set in motion, it is subjected to all the hindrances in the waterway, such as friction, gravity, short bends, etc. $\text{STATIC MINUS RESIDUAL} = \text{FLOW}$

(c) Residual Pressure

Is what is left, or the pressure remaining in the mains after the valve is opened and water is flowing. The intake gauge on the pumper should not show less than 35 kPa residual pressure

(1986)

6. FRICTION LOSS

Friction loss has become a common term in the fire service, especially to those responsible for producing fire streams. All in all, it is taken to mean the loss in the stream pressure in the entire waterway from pump to nozzle, and even through the pump

Theoretically, friction loss in a fire stream is due to the friction of the water upon the different part of the waterway such as the interior surface of the hose, couplings, valves, gaskets in couplings, hose appliances, etc. It is an ever-present force and must be overcome.

Friction loss is always measured in Pascals or derivations of Pascals, the commonest being the kilo Pascal or kPa.

Friction loss increases as the discharge increases.

Friction loss increases as the velocity increases.

Friction loss increases as the hose diameter decreases.

Friction loss increases as the hose length increases.

Friction loss increases as the nozzle pressure increases.

Friction loss increases when internal roughness of hose increases.

90% of hydraulics concerns friction loss in various hose layouts. The key is to find the friction loss per 30 m length of hose.

HINDERING FORCES

There are two types of hindering forces to be overcome, external and internal.

- (a) External hindering forces are those forces acting on the water as it travels from the nozzle to the fire. They are: gravity, resistance of air, wind, heat, distance of travel. They are overcome by providing adequate pressure at the nozzle.

(1986)

- (b) Internal hindering forces are those forces acting on the water as it travels through the hose line from the pump to the nozzle. They are friction loss and gravity due to head or elevation.

7. ESTABLISHING PUMP PRESSURE

In order to establish an efficient pump pressure, the operator must know the following facts:

- (a) The litres per minute discharge of the nozzle
- (b) The diameter of the hose line
- (c) The length of the hose line
- (d) The friction loss each 30 metres of hose
- (e) The friction loss of appliances
- (f) Any elevation that the nozzle is taken above the level of the pump discharge or, conversely, below the level of the pump discharge

From this, the operator can determine how much pressure to allow for the three components which make up the pump pressure, namely: nozzle pressure, allowance for head and total friction loss in the hose line. The nozzle pressure will be an appropriate standard pressure for the type of nozzle used, allowance for head is made at the rate of 10 kPa for every metre of elevation and friction loss is calculated by using predetermined friction loss constants calculated by using the appropriate formulas.

8. NOZZLE PRESSURE

65 mm hose lines employing "open tip" nozzles are operated at 350 kPa.

Master streams are those employing open tip nozzles larger than 29 mm or large litre fog nozzles. All fog nozzles operate at 700 kPa pressure and all master stream open tips operate at 550 kPa nozzle pressure.

(1986)

PART I

SECTION 2

1. HYDRAULIC FORMULAS

'A' 'Q' FACTOR

$$Q = \frac{\text{LITRES/MINUTE}}{100}$$

'B' FRICTION LOSS PER 30 METRES OF 25 MILLIMETRE HOSE

$$\text{F.L.} = 140 Q^2 \quad (\text{UNITS} = \text{kPa})$$

'C' FRICTION LOSS PER 30 METRES OF 38 MILLIMETRE HOSE

$$\text{F.L.} = 13 Q^2 \quad (\text{UNITS} = \text{kPa})$$

'D' FRICTION LOSS PER 30 METRES OF 65 MILLIMETRE HOSE

$$\text{F.L.} = Q^2 + Q \quad (\text{UNITS} = \text{kPa})$$

'E' FRICTION LOSS PER 30 METRES OF 77 MILLIMETRE HOSE

$$\text{F.L.} = \frac{Q^2}{3} + Q \quad (\text{UNITS} = \text{kPa})$$

'F' FRICTION LOSS PER 30 METRES OF 100 MILLIMETRE HOSE

$$\text{F.L.} = \frac{Q^2}{10} + Q \quad (\text{UNITS} = \text{kPa})$$

(1986)

'G' PUMP PRESSURE

$$P.P. = N.P. + F.L/30M \times LAY/30M + ELEVATION$$

P.P. = PUMP PRESSURE (UNIT = kPa)
N.P. = NOZZLE PRESSURE (UNIT = kPa)
F.L/30M = FRICTION LOSS PER 30M OF HOSE (UNIT = kPa)
LAY/30M = LENGTH OF HOSE LAY DIVIDED BY 30M OR ONE
HOSE LENGTH (UNIT = METRES)
ELEVATION = PRESSURE LOST OR GAINED DUE TO ELEVATION
(UNITS = kPa)

'H'1 NOZZLE REACTION FOR STRAIGHT STREAM

$$N.R. = 0.0015 D^2 N.P.$$

N.R. = NOZZLE REACTION (UNIT = NEWTONS)
 D^2 = DIAMETER OF THE NOZZLE TIMES ITSELF
(UNIT = MM)
N.P. = NOZZLE PRESSURE (UNIT = kPa)

#2 NOZZLE REACTION FOR FOG STREAM

$$N. R. = \frac{L/MIN}{64} \sqrt{N.P.}$$

N.R. = NOZZLE REACTION (UNIT = NEWTONS)
N.P. = NOZZLE PRESSURE (UNIT = kPa)
L/MIN = LITRES PER MINUTE

(1986)

'I' FLOW OR LITRES/MINUTE FROM AN OPEN TIP NOZZLE

$$L/\text{MIN} = 0.06 D^2 \sqrt{N.P.}$$

L/MIN = LITRES PER MINUTE FLOWING
D² = DIAMETER OF NOZZLE TIMES ITSELF (UNIT = MM)
N.P. = NOZZLE PRESSURE (UNIT = kPa)

'J' FLOW OR LITRES/MINUTE FROM HYDRANT BUTT

$$L/\text{MIN} = 242 \sqrt{F.P.}$$

L/MIN = LITRES PER MINUTE FLOWING
F.P. = FLOW PRESSURE FROM HYDRANT (UNIT = kPa)

'K' FLOW OR LITRES/MINUTE FROM SPRINKLER HEAD (12.7MM ORIFICE)

$$L/\text{MIN} = \frac{P}{3} + 68$$

L/MIN = LITRES PER MINUTE FLOWING
P = SPRINKLER HEAD PRESSURE (UNIT = kPa)

(1986)

'L' TO FIND LITRES IN A TANK

NOTE:

1 CUBIC DECIMETER (0.1 M) OF WATER WEIGHS 1 KILOGRAM (1000 G) AND 1 KILOGRAM (1000 G) OF WATER CONTAINS 1 LITRE OF WATER

THEREFORE FOR EACH CUBIC DECIMETER (0.1 M) CALCULATED IT CONTAINS 1 LITRE OF WATER, AND HAS A MASS OF 1 KILOGRAM (1000 G) ETC:

120 CUBIC DECIMETRES = 120 LITRES = 120 KILOGRAMS

#1 SQUARE TANK

CUBIC AREA OF TANK = L X W X D

L = LENGTH (UNIT = DECIMETRES)

W = WIDTH (UNIT = DECIMETRES)

D = DEPTH (UNIT = DECIMETRES)

CUBIC AREA = (UNITS = CUBIC DECIMETRES OF DM^3)

CUBIC AREA (DM^3) = LITRES OF WATER = MASS OF WATER (KILOGRAMS)

#2 CIRCULAR TANK

CUBIC AREA OF TANK = D^2 X 0.7854 X D

D^2 = DIAMETER OF TANK TIMES ITSELF (UNIT = DECIMETRES)

D = DEPTH OF TANK (UNIT = DECIMETRES)

CUBIC AREA = (UNITS = CUBIC DECIMETRES OR DM^3)

CUBIC AREA (DM^3) = LITRES OF WATER = MASS OF WATER (KILOGRAMS)

#3 TRIANGULAR TANK

CUBIC AREA OF TANK = $\frac{1}{2}$ X B X H X D

B = BASE OF TRIANGLE (UNIT = DECIMETRES)

H = HEIGHT OF TRIANGLE (UNIT = DECIMETRES)

D = DEPTH OF TRIANGULAR BASIN (UNIT = DECIMETRES)

CUBIC AREA (UNITS = CUBIC DECIMETRES OR DM^3)

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'M' LINES SIAMESED

1/ 2 LINES SIAMESES INTO 1 LINE - DIVIDED F.L.
IN 1 LINE BY 4

2/ 3 LINES SIAMESES INTO 1 LINE - DIVIDED F.L.
IN 1 LINE BY 8

'N' TO CALCULATE ADDITIONAL DELIVERY FROM HYDRANT UNDER
EXISTING CONDITIONS

(A) SUBTRACT RESIDUAL PRESSURE FROM STATIC
PRESSURE TO OBTAIN DROP (DISCHARGE LINE(S)
OPEN AND AT PROPER PRESSURE(S)).

(B) DETERMINE PERCENTAGE OF DROP AS FOLLOWS:

$$\text{PERCENTAGE DROP} = \frac{\text{DROP}}{\text{STATIC}} \times 100$$

(C) APPLY FOLLOWING RULE:

40% DROP = NO ADDITIONAL LINES

20% DROP = 1 MORE LINE OF SAME CAPACITY

10% DROP = 2 MORE LINES OF SAME CAPACITY

7% DROP = FULL CAPACITY AVAILABLE

(1986)

PART I

SECTION 3

CONSTANTS: METRIC HYDRAULIC INFORMATION ON HOSE LAYS AND EQUIPMENT NECESSARY FOR THE EFFICIENT OPERATION OF A PUMP (ETC. PUMP PRESSURES, L/MIN, NOZZLE PRESSURES, FRICTION LOSS)

NOTE: ALL FIGURES ARE APPROXIMATE OR ROUNDED OFF.
THEY ARE NOT THE EXACT CALCULATED FIGURES BUT
ARE TO BE USED FOR FIRE GROUND PURPOSES.

'A' STANDARD NOZZLE PRESSURES

NOZZLE	NOZZLE PRESSURES
OPEN TIP HAND LINE	350 kPa
OPEN TIP MASTER STREAMS	550 kPa
FOG NOZZLES	700 kPa

'B' 25 mm HOSE WITH FOG NOZZLE

LENGTH	L/MIN	F.L./30M	NOZZLE PRESSURE	PUMP PRESSURE
60m, 75m	90L	115 kPa	700 kPa	1,000 kPa

(1986)

'C' 38mm HOSE WITH FOG NOZZLE

LENGTH	L/MIN	F.L./30M	NOZZLE PRESSURE	PUMP PRESSURE
30 m	360L	170 kPa	700 kPa	870 kPa
60 m	360L	170 kPa	700 kPa	1000 kPa
90 m	360L	170 kPa	700 kPa	1200 kPa

'D' 65mm HOSE WITH FOG NOZZLE

LENGTH	L/MIN	F.L./30M	NOZZLE PRESSURE	PUMP PRESSURE
30 m	750L	60 kPa	700 kPa	760 kPa

'E' EXPOSURE NOZZLES

SIZE	L/MIN	F.L./30M	NOZZLE PRESSURE
38 mm	360L	170 kPa	700 kPa
65 mm	900L	90 kPa	700 kPa

'F' ELKART CELLAR NOZZLE

SIZE	L/MIN	F.L./30M	NOZZLE PRESSURE
65 mm	900L	90 kPa	700 kPa

(1986)

'G' OPEN TIP NOZZLES

DIA	L/MIN	NOZZLE	FRICTION LOSS	
		PRESSURE	SINGLE LINE 65mm	SINGLE LINE 77mm
25mm	700 L	350 kPa	60 kPa	20 kPa
29mm	1000 L	350 kPa	110 kPa	40 kPa
32mm	1400 L	550 kPa	210 kPa	70 kPa
35mm	1700 L	550 kPa	300 kPa	100 kPa
38mm	2000 L	550 kPa	420 kPa	140 kPa
44mm	2700 L	550 kPa	760 kPa	250 kPa
51mm	3700 L	550 kPa	1400 kPa	470 kPa

NOTE: WHEN USING OPEN TIPS WITH A DELUGE ADD 150 kPa TURBULANCE TO GET YOUR BASIC PRESSURE. (150 kPa was arrived at averaging 5% of the flow rate of all the open tip flow rates)

'H' 65 mm HOSE LINES WYED DOWN TO 1 OR MORE 38mm HOSE LINES WITH FOG NOZZLES>

NO. OF 38mm LINES	F.L. IN 65 MM LINE PER 30 M	L/MIN 38mm fog	F.L. IN 38mm LINE PER 30 M
1	20 kPa	360 L	170 kPa
2	60 kPa	720 L	170 kPa
3	130 kPa	1080 L	170 kPa

(1986)

'I' 77mm HOSE LINE WYED DOWN TO 1 OR MORE
38mm HOSE LINES WITH FOG NOZZLES

NO. OF 38mm LINES	F.L IN 77mm LINE PER 30M	L/MIN 38mm fog	F.L IN 38mm LINE PER 30M
1	6 kPa	360 L	170 kPa
2	20 kPa	720 L	170 kPa
3	40 kPa	1080 L	170 kPa

'J' AERIAL WATER TOWER BASIC PRESSURES

SIZE	BASIC PRESSURE (45m OF 77MM hose, 30m extension)	FRICTION LOSS 30m-77mm hose	FRICTION LOSS 30m-65mm hose	L/MIN
38 mm	1200 kPa	140 kPa	420 kPa	2000 L
44 mm	1400 kPa	250 kPa	760 kPa	2700 L
51 mm	1700 kPa	470 kPa	1400 kPa	3700 L
J200	1300 kPa	130 kPa	380 kPa	1900 L

BASIC PRESSURE = NOZZLE FRICTION LOSS + TURBULANCE + ELEVATION
PRESSURE (45m-77mm hose) (5% of L/MIN) (30m ext.)

NOTE: 2 LINES SIAMESED - DIVIDE F.L BY 4
3 LINES SIAMESED - DIVIDE F.L BY 8

NOTE: Friction loss due to elevation is 10 kPa/metre
therefore 30m extension of aerial is $30 \times 10 = 300$ kPa

(1986)

'J' AERIAL WATER TOWER BASIC PRESSURES (Cont'd)

To calculate the basic pressure for aerials not extended the full 30 metres subtract 10 kPa/metre not extended. etc.

AERIAL WITH J200 EXTENDED 15 METRES

Basic pressure for J200 with 30 metre extension=1300 kPa
therefore (30m - 15m) x 10 kPa/metre = 150 kPa
therefore 1300 kPa - 150 kPa = 1150 kPa for 15 metre extension with J200 nozzle.

'K' DELUGE EQUIPMENT WITH LARGE CAPACITY FOG NOZZLE (J200, JN200)

NOZZLE	TURBULANCE	BASIC PRESSURE		F.L PER 30m HOSE		
				SIAMESED		
NOZZLE PRESSURE 5% of L/MIN	5% of L/MIN	(N.P + TURB) L/MIN		2-65mm	3-65mm	3-77mm
J200	700 kPa	100 kPa	800 kPa	1900L	100kPa	50kPa 15kPa
JN200	700 kPa	200 kPa	900 kPa	3800L	370kPa	200kPa 60kPa

'L' PUMP PRESSURE FOR PUMPING INTO STANDPIPE AND SPRINKLER SYSTEMS

SYSTEM	PUMP PRESSURE		
STANDPIPE SYSTEM PER FLOOR	700 kPa	+	30 kPa
SPRINKLER SYSTEM PER FLOOR	700 kPa	+	30 kPa

'M' #1. PRESSURE LOSS DUE TO ELEVATION USE:

10 kPa/METRE OR 30 kPa/STOREY
UNITS = kilopascals

(1986)

#2. PRESSURE LOSS DUE TO TURBULANCE IN APPLIANCES:

LOSS DUE TO TURBULANCE = 5% OF THE FLOW RATE

(UNITS = kPa) (UNITS = kPa)

NOTE: USE 150 kPa FOR LOSS DUE TO TURBULANCE
WHEN USING A DELUGE SET WITH AN OPEN TIP
NOZZLE.

#3. RESIDUAL PRESSURE FOR RELAY USE:
150 kPa

'N' BASIC PRESSURES FOR SNORKEL

NOTE: BASIC PRESSURE AT GROUND INTAKE REMAINS THE SAME, AS
1,137 kPa IS SUFFICIENT TO SUPPLY THE J200 FOG NOZZLE
AND THE SPRINKLER NOZZLE. DON'T EXCEED 1400 kPa.

- EXPOSURE NOZZLE HAS 375 L/MIN FLOW

SIZE AND NO. NOZZLES USED	BASIC PRESSURE	FRICITION LOSS 30m-77m HOSE	FRICITION LOSS 30m-65mm HOSE	L/MIN
1-J200	1137 kPa	130 kPa	380 kPa	1900L
J200 + 1 exposure nozzle	1137 kPa	180 kPa	540 kPa	2275L
1-38mm LINE off wye in basket	1137 kPa	6 kPa	16 kPa	360L
2-38mm LINES off wye in basket	1137 kPa	20 kPa	60 kPa	720L
1-65mm off port	1137 kPa	20 kPa	65 kPa	750L

(1986)

'O' BASICS FOR SQUIRT (PUMP #2)

WITH BOOM AT MAXIMUM HEIGHT AND NOZZLE SET AT:

MAXIMUM FLOW 1100 kPa = 3800 L/MIN

MINIMUM FLOW 700 kPa = 1100 L/MIN

WITH BOOM AT MINIMUM HEIGHT AND NOZZLE SET AT:

MAXIMUM FLOW 1000 kPa = 3800 L/MIN

MINIMUM FLOW 600 kPa = 1100 L/MIN

'P' PRESSURE REQUIREMENTS FOR FOAM EQUIPMENT

#1. DOUBLE TUFF NOZZLE AND EDUCTOR

In-Line Eductor 65mm - 65mm

-Pressure at eductor - 1400 kPa

-Hose lay limits - 450 L/MIN @ 360m

In-Line Eductor 65mm - 38mm

-Pressure at eductor - 1400 kPa

-Hose lay limits - 360 L/MIN @ 45m

#2. FOAM HIP PAK

-Pressure at eductor - 700 kPa

-Consumes 9 Litres of foam concentrate solution
in 4 minutes producing 3200 Litres of foam.

(1986)

#3. JET X IN-LINE EDUCTOR

- Pressure at eductor - maximum - 1750 kPa
- average - 1400 kPa
- minimum - 1050 kPa

- Maximum Lay between eductor and nozzle
- 150 metre 38mm hose

#4. M.S.A. FOAM MAKER

- Pressure at foam maker - 420 kPa
- Water supply at foam maker - 140 L/MIN
- Foam Capacity - 14000 L/MIN

'Q' CAPACITY OF CLASS 'A' PUMP

100%	AT	1000 kPa
70%	AT	1350 kPa
50%	AT	1700 kPa

CLASS 'A' PUMP = 5000 L/MIN CAPACITY

100% CAPACITY	=	5000 L/MIN	@	1000 kPa
70% CAPACITY	=	3500 L/MIN	@	1350 kPa
50% CAPACITY	=	2500 L/MIN	@	1700 kPa

(1986)

PART I

SECTION 4

1. SAMPLE PROBLEMS

'A' Find the pump pressure for supplying a 75 metre line 25 mm in diameter with a fog nozzle at the end.

ANSWER:

L/MIN FOR 25mm fog nozzle = 90 L (constant)

Length = 75 m

N.P. = 700 kPa (constant for fog nozzle)

DIA = 25mm

$$\begin{aligned} \text{F.L./30m of 25mm hose} &= 140 Q^2 & Q &= \frac{\text{L/MIN}}{100} \\ &= 140 \times .9 \times .9 & &= \frac{90}{100} = .9 \\ &= 115 \text{ kPa} \end{aligned}$$

$$\begin{aligned} \text{PUMP PRESSURE} &= \text{N.P.} + \text{F.L./30m} \times \text{LAY/30m} \\ &= 700 + 115 \times \frac{75}{30} \\ &= 700 + 288 \\ &= 988 \text{ kPa (Fire Ground Pump Pressure = 1000 kPa)} \end{aligned}$$

(1986)

'B'

Find the Pump Pressure for supplying a 90 metre line 38mm diameter with a fog nozzle at the end.

ANSWER:

L/MIN FOR 38mm FOG NOZZLE = 360 L
(constant)

Length = 90m

N.P. = 700 kPa (constant for fog
nozzle)

Dia = 38mm

F.L/30m of 38mm hose = 13 Q²

Q = $\frac{L/MIN}{100}$

= 13 X 3.6 X 3.6 = $\frac{360}{100} = 3.6$

= 170 kPa

PUMP PRESSURE = N.P. + F.L/30m X LAY/30m

= 700 + 170 X $\frac{90}{30}$

= 700 + 170 X 3

= 1210 kPa (F.G.F. as per chart
= 1200 kPa)

(1986)

'C'

Find the pump pressure for supplying a 90 metre line 65mm in diameter with a fog nozzle at the end.

ANSWER:

L/MIN FOR 65mm FOG NOZZLE = 750 L
(constant)

Length = 90m

N.P. = 700 kPa (constant for fog
nozzle)

Dia = 65mm

$$\begin{aligned} \text{F.L./30m of 65mm hose} &= Q^2 + Q & Q &= \frac{L/\text{MIN}}{100} \\ &= 7.5 \times 7.5 + 7.5 & &= \frac{750}{100} = 7.5 \\ &= 56 + 7.5 \\ &= 63.5 \text{ kPa (F.G.F. as per chart = 60} \\ &\quad \text{kPa)} \end{aligned}$$

$$\begin{aligned} \text{PUMP PRESSURE} &= \text{N.P.} + \text{F.L./30m} \times \text{LAY/30m} \\ &= 700 + 65 \times \frac{90}{30} \\ &= 700 + 65 \times 3 \\ &= 700 + 195 \\ &= 895 \text{ kPa} \end{aligned}$$

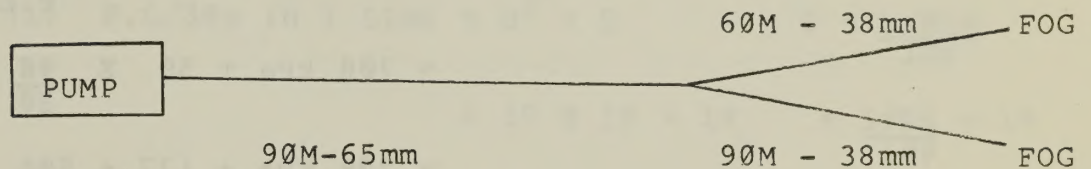
(1986)

'D'

Find the pump pressure for a 90 metre - 65mm dia line feeding 2 - 38mm dia lines.

1st line - 90 metre - 38mm dia with a fog nozzle

2nd line - 60 metre - 38mm dia with a fog nozzle



ANSWER: L/MIN in 38mm hose = 360 L (constant)
N.P. = 700 kPa (constant for fog nozzle)

$$\begin{aligned}
 (1) \quad \text{F.L./30m in the 90m - 65mm line} &= Q^2 + Q \quad Q = \frac{\text{L/MIN}}{100} \\
 &= 7.2 \times 7.2 + 7.2 = \frac{\text{L/MIN} \#1 + \#2}{100} \\
 &= 52 + 7.2 = \frac{360 + 360}{100} \\
 &= 59 \text{ kPa} \quad = 7.2
 \end{aligned}$$

$$\begin{aligned}
 (2) \quad \text{F.L./30m in 90m - 38mm line} &= 13 Q^2 \quad Q = \frac{\text{L/MIN}}{100} \\
 &= 13 \times 3.6 \times 3.6 = \frac{360}{100} = 3.6 \\
 &= 168 \text{ kPa}
 \end{aligned}$$

(1986)

(3) F.L./30m in 60m - 38mm line = 168 kPa (same F.L./30m as the other 38mm line)

PUMP PRESSURE LINE #1 = N.P. + F.L. IN 90m - 65mm Line +
F.L. in LINE #1

$$= 700 \text{ kPa} + 59 \times \frac{90}{30} + 168 \times \frac{90}{30}$$

$$= 700 \text{ kPa} + 177 + 504$$

$$= 1381 \text{ kPa}$$

PUMP PRESSURE LINE #2 = N.P. + F.L. IN 90m - 65mm LINE +
F.L. in LINE #2

$$= 700 \text{ kPa} + 59 \times \frac{90}{30} + 168 \times \frac{60}{30}$$

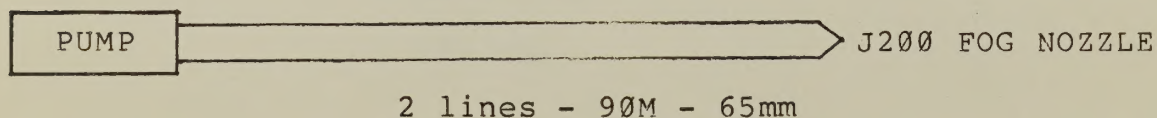
$$= 700 \text{ kPa} + 177 + 336$$

$$= 1213 \text{ kPa}$$

THEREFORE:

Set pump pressure at the highest pressure required on the longest line - SET TO LINE #1 1381 kPa

'E' Find the pump pressure for 2 - 90m lines 65mm in diameter siamesed to a deluge with a J200 fog nozzle.



(1986)

ANSWER:

L/MIN IN J200 fog nozzle = 1900 L (constant)

N.P. FOR J200 fog nozzle = 700 kPa (constant)

$$\begin{aligned}(1) \quad \text{F.L./30m IN 1 LINE} &= Q^2 + Q & Q &= \frac{\text{L/MIN}}{100} \\ &= 19 \times 19 + 19 & &= \frac{1900}{100} = 19 \\ &= 380 \text{ kPa}\end{aligned}$$

F.L./30m WITH 2 LINES SIAMESED YOU DIVIDE BY 4

$$\text{THEREFORE } \frac{380}{4} = 95 \text{ kPa PER 30m}$$

$$\begin{aligned}(2) \quad \text{BASIC N.P. FOR J200 WITH DELUGE} &= \text{N.P.} + \text{TURBULANCE} \\ &= 700 \text{ kPa} + 100 \text{ kPa} \\ &= 800 \text{ kPa}\end{aligned}$$

$$\begin{aligned}\text{PUMP PRESSURE} &= \text{BASIC N.P.} + \text{F.L./30m} \times \text{LAY/30m} \\ &= 800 + 95 \times \frac{90}{30} \\ &= 800 + 285 \\ &= 1085 \text{ kPa}\end{aligned}$$

'F' Find the Basic Pressure for an aerial extended 30 metres, with 45 metres of 77mm hose supplying a J200 fog nozzle at the end of the aerial.

ANSWER:

L/MIN IN J200 fog nozzle = 1900 L (constant)

N.P. for J200 fog nozzle = 700 kPa (constant)

(1986)

$$(1) \text{ F.L./30m in 77mm hose} = \frac{Q^2}{3} + Q \quad Q = \frac{L/\text{MIN}}{100}$$

$$= \frac{19 \times 19 + 19}{3} = \frac{1900}{100} = 19$$

$$= \frac{380}{3}$$

$$= 127 \text{ kPa}$$

$$(2) \text{ LOSS DUE TO ELEVATION} = 10 \text{ kPa PER METRE}$$

$$= 30 \text{ metre extension} \times 10$$

$$= 300 \text{ kPa}$$

$$(3) \text{ LOSS DUE TO TURBULANCE} = 5\% \text{ of FLOW}$$

$$= .05 \times 1900$$

$$= 95 \text{ kPa}$$

$$\text{PUMP PRESSURE} = \text{N.P.} + \text{TURBULANCE} + \text{F.L./30m} \times \text{LAY/30m} + \text{ELEV.}$$

$$= 700 + 95 + \left(127 \times \frac{45}{30}\right) + 300$$

$$= 700 + 95 + 190 + 300$$

$$= 1285 \text{ kPa (fire ground figure as per chart = 1300 kPa)}$$

(1986)

'G' Find the pump pressure for supplying a 90 metre line with a 38mm open tip nozzle at the end.

ANSWER:

LENGTH = 90m

N.P. = 550 kPa (constant for master stream open tip)

Dia = 38mm

L/MIN FOR A 38mm OPEN TIP = 2000 L (constant)

F.L/30m of 65mm hose = $Q^2 + Q$ $Q = \frac{L/MIN}{100}$

$$= 20 \times 20 + 20 = \frac{2000}{100} = 20$$

$$= 420 \text{ kPa}$$

PUMP PRESSURE = N.P. + F.L/30m x LAY/30m

$$= 550 + 420 \times \frac{90}{30}$$

$$= 550 + 1260$$

$$= 1810 \text{ kPa}$$

'H' Find the nozzle reaction of a 25mm open tip nozzle hand line.

ANSWER:

N.P. = 350 kPa (constant)

N.R. = $0.0015 d^2 \times N.P.$
 $= 0.0015 \times 25 \times 25 \times 350$
 $= 328 \text{ Newtons}$

(1986)

'I' Find the nozzle reaction of a 65mm fog nozzle.

ANSWER:

$$\text{N.P.} = 700 \text{ kPa (constant for fog nozzle)}$$

$$\text{L/MIN} = 750 \text{ L (constant for 65mm hose with fog)}$$

$$\text{N.R.} = \frac{\text{L/MIN} \times \text{N.P.}}{64}$$

$$= \frac{750 \times 700}{64}$$

$$= 310 \text{ Newtons}$$

'J' Find the Litres per minute flowing from a 25mm open tip nozzle.

$$\text{N.P} = 350 \text{ kPa (constant for 25mm open tip)}$$

$$\begin{aligned} \text{L/MIN} &= 0.06 d^2 \sqrt{\text{N.P}} \\ &= 0.06 \times 25 \times 25 \times \sqrt{350} \\ &= 700 \text{ Litres per minute flowing} \end{aligned}$$

'K' Find the Litres per minute flowing from a 68mm hydrant butt with a flow pressure reading of 250 kPa.

$$\begin{aligned} \text{L/MIN} &= 242 \times \sqrt{\text{F.P}} \\ &= 242 \times \sqrt{250} \\ &= 3826 \text{ Litres per minute flowing} \end{aligned}$$

'L' Find the Litres per minute flowing from a 12.7mm orifice of a sprinkler head with a pressure reading of 200 kPa.

$$\begin{aligned} \text{L/MIN} &= \frac{P}{3} + 68 \\ &= \frac{200}{3} + 68 = 135 \text{ Litres per minute flowing} \end{aligned}$$

'M' Find the Litres of water, and the weight of the water in a circular tank with a diameter of 30 decimeters (3.0 metres) and a depth of 15 decimeters (1.5 metres) which is considered to be full.

(1986)

NOTE:

1 cubic decimeter 1 Litre of 1 Kilogram of
of water = water = water

CUBIC AREA OF TANK = $D^2 \times 0.7854 \times \text{DEPTH}$
= $30 \times 30 \times .7854 \times 15$
= 10,600 cubic decimeters or dm^3

THEREFORE:

CUBIC AREA OF TANK = 10,600 CUBIC DECIMETERS
LITRES OF WATER IN TANK = 10,600 LITRES
WEIGHT OF WATER IN TANK = 10,600 KILOGRAMS

RELAY FORMULAS

'A' DISTANCE BETWEEN PUMPERS

1. To establish this factor use N.P. of 350 kPa for hand line, 550 kPa for master streams, and 700 kPa for fog nozzles.
2. From N.P. deduct residual pressure of 150 kPa.
3. Divide the remainder by the friction loss in the 65mm line.
4. Multiply this factor that you have now determined by 30 and add this figure to the overall distance of hose required from the source of supply to the fire.
5. The final step will be to divide the calculated distance by the number of pumpers available. This figure will equal the distance in metres between pumpers.

HOSE LAY BETWEEN = $(\text{OVERALL DISTANCE}) + \frac{((\text{N.P.} - \text{R.P.}) \times 30)}{\text{F.L./30m in 65mm hose}}$
PUMPERS REQUIRED NUMBER OF PUMPS AVAILABLE

N.P.= nozzle pressure (units = kPa)

R.P.= residual pressure (units = kPa)

OVERALL DISTANCE REQUIRED = is the distance from the source
of supply to the fire (units = metres)

(1986)

PUMPER PRESSURE FOR SOURCE PUMPS

PUMP PRESSURE = HOSE LAY BETWEEN PUMPERS X F.L/30m + R.P.

F.L/30m = friction loss per 30 metre length of hose

R.P. = residual pressure (150 kPa)

PUMPER PRESSURE FOR FIRE PUMP

PUMP PRESSURE = N.P. + F.L. OF HOSE FROM THE FIRE PUMP
TO NOZZLE + ELEVATION

N.P. = nozzle pressure

F.L. = friction loss

CHAPTER 11

FIRE STREAMS

PRINCIPLES IN THE APPLICATION OF WATER FOG IN FIRE FIGHTING OPERATIONS

PART II

1. INTRODUCTION:

Well over 90% of all fires are controlled and extinguished with water. Since water is the most used extinguishing agent, firefighting personnel must fully understand the scientific principles involved as well as the practical application of water in its various forms under any fire conditions. No other extinguishing agent is available in such abundant and economical supplies. No other extinguishing agent possesses the ability to control or extinguish even an average dwelling fire.

The full extinguishing capacity of water has only recently been recognized by the fire service. Even today, many fire departments allow the newest recruits to direct fire streams at fires, whereas, in actual fact, the nozzleman should be a man thoroughly trained and experienced in the art of obtaining the maximum extinguishing efficiency from the water available to him.

2. FACTORS RELATED TO HEAT ABSORBING ABILITY OF WATER

Oxygen and fuel are present almost everywhere on earth, yet fire only occurs when excessive heat combines with the oxygen and fuel. Obviously, heat causes most fires, therefore, most fires can be controlled by eliminating the heat factor.

Heat is a form of energy that can be and is detected by humans through the sense of touch. Heated materials change shape, colour and may even become invisible. An increase in temperature causes most substances to change state from a solid to a liquid to a gas. Conversely, cooling reverses the procedure. When heat is applied to any substance, its molecules begin to vibrate more intensely. The intensity of these vibrations is measured in degrees of temperature. However, temperature does not indicate the total amount of heat over a given area.

We are concerned with the amount of energy in the fire area rather than the intensity of that energy. Amounts of energy are measured in Joules (J). It takes 4.2 kilo Joules (kJ) or 4,200 Joules to raise the temperature of one kilogram (or one litre) of pure water one celsius degree (1°C).

The heat absorbing ability of water and the heat generated by a fire can only be accurately measured in J or kJ. The rate of heat absorption of water can be greatly increased by breaking the water into finely divided particles thereby exposing more surface area to contact with the heat.

Water fog cannot be effectively applied to a fire unless the methods by which heat travels from one location to another is understood. This heat transfer occurs in three ways:

- (a) Convection - heated atmosphere expands becoming lighter and rises to the ceiling. The heavier, cooler atmosphere flows downwards replacing the heated air.
- (b) Conduction - heat applied to a solid material will travel along the material following the path of the conductor regardless of the direction.
- (c) Radiation - heat will radiate equally in all directions in clean air. Radiant heat can be compared to light emanating from a light bulb.

NOTE: For complete definitions of convection, conduction and radiation, refer to Fire Behaviour chapter.

3. PRINCIPLES OF WATER FOG EXTINGUISHMENT

Litre for Litre, water applied to a fire in the form of fog is considerably more effective under proper conditions than the solid stream method. The superior effectiveness of fog is due to the two major extinguishing effects; namely, (1), the greater heat absorption by the water and (2) the tremendous expansion of the water when it converts to steam.

(1986)

HEAT ABSORPTION PROCESS

A burning material must be cooled below its ignition temperature before extinguishment can be achieved. Therefore, the more kJ absorbed by the water, the more effective is the extinguishment. The full process of what happens to water when it absorbs heat is described in the following example.

If a kilogram of water is heated so that the temperature is raised from 15°C to 100°C (boiling point), the water will absorb 357 kJ (4.2 kJ for every degree it is raised). When the water reaches the boiling point, it will turn to steam if enough heat energy is present to overcome the "latent heat of vapourization". The latent heat of vapourization for water is 2250 kJ per kg.

Thus, the following absorption takes place:

1 Litre (1 kg) of water heated from 15°C to 100°C =	357 kJ
1 Litre (1 kg) of water converted to steam =	<u>2250 kJ</u>
TOTAL	2607 kJ

A 38 mm fog nozzle will deliver 360 L/min. If this were converted to steam, the heat absorbed would be 2607 X 360 = 938,520 kJ.

The foregoing example illustrates that water achieves its maximum extinguishing effect at the instant the water converts to steam. This principle is the secret of the extraordinary success of water fog. It naturally follows that the primary objective of a nozzleman is to produce as much steam as possible from the water available to him.

(1986)

WATER TO STEAM EXPANSION PROCESS

The foregoing has emphasized the heat absorbing ability of water. However, a secondary effect occurs when water changes to steam which also contributes much to the success of fog fire fighting. This secondary effect results from the fact that water expands approximately 1600 times when it is converted to steam.

For example, each dm^3 (or Litre) of water when introduced into a heated room will expand into 1600 dm^3 of steam (or 1.6 m^3), thereby displacing an equal amount of interior atmosphere. This internal generation of steam purges the room of much of the heat, smoke, fire gases, toxic gases and air - all of which either contribute to the fire or hinder fire fighting operations. We now have a room full of steam and combustion cannot survive in an atmosphere of steam.

Occasionally fire fighters have been surprised to find that fog will extinguish fires in areas other than where the fog is being introduced. This desirable condition results from the expansion process in which all the steam being produced cannot be contained in the one room whereupon it expands into other rooms extinguishing fire in remote areas on the same level or above. Also, some of the fog particles may be carried on air currents to these remote areas where they are converted to steam if sufficient heat is present.

The expansion of water fog and resultant purging of the interior atmosphere provides a far more efficient method of ventilating the fire area than conventional methods of ventilation (vertical and horizontal). Conventional methods of ventilation accomplish little when used in conjunction with water fog attacks on fires. In fact, ventilation defeats the success of fog fire fighting. Conventional ventilation practices should only be used with water fog under the following conditions:

- (a) Where the fire has not generated enough heat to convert the water fog into steam.
- (b) When the initial water fog attack has been completed and it is desirable to reduce temperature and humidity, increase visibility and generally improve the internal atmosphere.

(1986)

4. THERMAL BALANCE

This term simply means that the atmosphere in any given enclosure is in normal balance with respect to temperature - the highest temperature is evenly distributed at ceiling height and the lowest temperature at floor level.

This balance is achieved naturally because of the relationship between the temperature of a gas and its density.

Heated gases rise to the highest level permitted, and cooler denser gases remain at the lower level.

A room or area will be in thermal balance under normal or non-fire conditions. Ceiling temperature will be around 23°C while floor temperature will be 19°C . The temperature differential is very little.

Under fire conditions, the atmosphere would still maintain a state of thermal balance because of the thermal currents set up by the fire; however, the temperature would be higher, and the temperature gradient would be much greater between ceiling and floor levels.

The ideal results we wish to achieve when making a fog attack, is to maintain the thermal balance in the fire area, through uniform cooling of the heated overhead.

When the fire area is left with an even ceiling temperature of approximately 121°C , conditions will be favourable for natural ventilation and effective overhauling.

On the other hand, when fog distribution has been poor, we would have part of the area cooled to near normal temperature while other parts are left with ceiling temperatures of around 537°C . When this has occurred, thermal balance has been upset. The strong thermal currents in the hot area will force the steam and smoke upward and laterally cross the ceiling into the area which has been cooled, where they will drop towards the floor. This turbulent circulation within the fire area will seriously limit visibility, make entry extremely difficult, and hamper ventilation. This situation is frequently caused through using too wide a fog pattern for the shape of the fire area, or by using opposing fog streams on a confined fire.

(1986)

The greater the heat differential within the fire area, the more violent will be the circulation. If cooling is continued on the perimeter of the fire through using too wide a pattern or nozzle with insufficient reach the portion of the fire not reached will gain in intensity, making it virtually impossible to enter the building.

Thermal imbalance can be readily spotted by the nozzleman making the attack. Immediately after closing off his nozzle, he will observe smoke and steam swirling downward just inside the opening through which he made his attack. This condition can sometimes be corrected and thermal balance restored by immediately making another short attack using a narrow fog pattern for greater reach and more uniform coverage.

5. IMPORTANCE OF FLOW

A large percentage of fires are lost each year because of a lack of knowledge concerning the amount of water required for a given fire. The whole problem of flow will be discussed under the following headings:

- (a) Insufficient Amounts of Water - Each fire generates a given amount of heat per minute and requires a given amount of water per minute to absorb this heat to effect extinguishment. A fire department is fighting a losing battle if the fire is generating more heat per minute than the water applied can absorb per minute. In an attempt to conserve booster tank water supplies, some fire departments attack fires with low flow nozzles thereby stretching the booster tank water supply to last for ten minutes but the building burns to the ground. If the rate of flow application was doubled or tripled, the tank would have emptied faster but the fire could probably have been extinguished.

(1986)

- (b) Too Much Water - Application of too much water beyond the blackening out effect defeats the purpose of water fog by condensing the generated steam which hinders the smothering action and returns the 2250 kJ/kg to atmosphere in the fire area. Condensation that is too rapid destroys the steam blanket too soon and allows cold air to enter and re-kindle the deep-seated burning. The water damage is increased and fire fighters have more difficulty entering and working in the fire area.
- (c) Ideal Amounts of Water - Proper rates of application will ensure sufficient heat absorption and steam generation. The steam blanket will slowly condense and contract causing fresh air to enter slowly allowing the heated atmosphere to rise to the ceiling permitting fire fighters to enter and work comfortably in the lower portion of the room.
- (d) Obtaining Ideal Flows - For years fire officers have been estimating the flow required for fires by experienced guesswork. Today, however, most of the guesswork can be eliminated by using a workable formula which provides a very accurate indication of the required Litres/min flow rate required for a given size of fire. The accuracy and efficiency of the formula depend on the fact that nozzles flowing at the stipulated rate must be shut off in 30 seconds. This is due to the results of tests that demonstrated that the amount of water must be distributed throughout the fire area in 30 seconds to achieve maximum efficiency. The formula and its practical application are as follows:

Litres/min rate of flow = volume of space involved in metres X 2.

Examples:

(1) Volume 3 m x 3 m x 3 m = 27 x 2
= 54 L/min flow rate

(2) Volume 30 m x 3 m x 3 m = 270 x 2
= 540 L/min flow rate

(1986)

(3) Volume 30 m x 30 m x 3 m = 2700 x 2
= 5400 L/min flow rate

(4) Volume 60 m x 60 m x 4 m = 14,400 x 2
= 28,800 L/min flow rate

The above examples illustrate that small flows can be supplied by one hose line. However, larger flows such as 28,800 L/min must obviously be supplied by many hose lines working in a coordinated attack.

6. WATER IN THE RIGHT FORM

Water must be in finely divided form in order to absorb the greatest amount of heat in the shortest period of time.

Nozzle design has a great influence on the size of water particles produced, and the nozzleman has no control over this, other than to select the most suitable nozzle design available.

However, the pump operator has a responsibility to the man on the nozzle, in that he must establish discharge pressures which will produce the best water particle size.

7. WATER IN THE RIGHT PLACE

Assuming the Officer has correctly assessed the number and size of fog streams required, and the pump operator has provided the desired nozzle pressures, rapid control and extinguishment will still depend on water being applied in the right place, using the correct pattern and application technique.

While this can become deeply involved in tactics, the main considerations are to inject the waterfog into the hottest areas, distribute the water particles uniformly throughout these areas, and maintain thermal balance.

This is ultimately the nozzleman's greatest responsibility, and they must be sufficiently knowledgeable about fire behaviour to accurately evaluate the existing fire condition.

(1986)

There are several physical problems that must be overcome if we are to achieve uniform distribution of water particles.

It does little good to know that 38mm fog nozzle has a sufficient rate of flow to control a given fire if the line cannot be advanced to the best vantage point because of wind direction.

It is equally futile trying to control a fire that could be extinguished with a 65 mm fog nozzle, if the nozzle has to be operated from a ladder, at some distances from the opening being used.

Both the examples cited present a situation where uniform water distribution throughout the fire area is virtually impossible. Many factors, such as height of structure, smoke, wind direction, unsafe structures, and lack of suitable openings, may prevent close approach to the fire area and the desired distribution of water fog cannot be achieved.

When conditions are such that fog nozzles, providing the necessary flow, can be advanced to the most advantageous point for attack, skillful handling of those nozzles will result in rapid control and make overhaul relatively easy.

VISIBLE SIGNS OF EFFECTIVE WATER APPLICATION

1. Smoke.
2. Smoke and steam.
3. Condensing steam.
4. Decrease in the amount of steam which:
 - a) Indicates a reduction of internal building temperature.
 - b) Assists in the ventilation process.

(1986)

There are several physical principles that govern the behavior of a system as it evolves. The first is the principle of conservation of energy.

It states that the total energy of a closed system remains constant. This means that energy cannot be created or destroyed, only transformed from one form to another.

Another important principle is the second law of thermodynamics, which states that the entropy of a closed system always increases over time. This means that the system becomes more disordered as it evolves.

These principles are fundamental to understanding the behavior of physical systems. They provide a framework for analyzing the evolution of a system and predicting its future state.

In the context of the study of the evolution of the universe, these principles are particularly important. They help us understand how the universe has changed over time and what its future might be.



THE EVOLUTION OF THE UNIVERSE

1. The Big Bang
2. The formation of the first stars and galaxies
3. The evolution of the universe over time
4. The future of the universe

FIRE STREAMS

CHAPTER 11

PRODUCING EFFECTIVE FIRE STREAMS

PART III

1. INTRODUCTION

Much discussion has taken place in the fire service as to which fire fighting subject is most important, excluding the saving of life. The answer to this question is not easily resolved because each subject is important and each is inter-dependent on all of the other subjects to ensure maximum efficiency. However, if a fire fighter analysed the situation by answering two basic questions, he must conclude that one particular subject seems to emerge as most important to the success of fire extinguishment.

The first question he must answer is: "What is the purpose of fire fighting?" The simplest answer to this question is: "To extinguish the fire as quickly as possible with the least amount of damage". The second question to answer is: "Then what, in the last analysis, actually extinguishes the fire?" The obvious answer to this question is: "The fire stream and the manner in which it is applied".

Since the production and application of effective fire streams determines the success of any fire fighting action, every fire fighter, from a chief officer to the newest recruit, must understand how to produce and apply each type of fire stream to obtain maximum efficiency.

2. DEFINITION AND PURPOSE OF FIRE STREAMS

A fire stream is considered to be a stream of water from a hose line after it leaves the nozzle and until it reaches the desired point of application. This stream of water, during the time it passes through space, is influenced by the forces of nature, such as gravity, wind, velocity and friction with the air. The condition of the stream when it leaves the nozzle is also influenced by the operating pressure, nozzle design, nozzle adjustment, and the condition of the nozzle tip.

The purpose of fire streams are:

- (a) To extinguish fire by applying water directly to the burning material,
- (b) To reduce high atmospheric temperature and to disperse hot smoke and fire gases caused by a fire in a confined space by applying it into the heated area,
- (c) To reduce the temperature over an open fire so as to permit closer approach of personnel with hand-lines to effect extinguishment,
- (d) To protect property exposed to fire by providing a heat-absorbing curtain of water.

3. TYPES OF FIRE STREAMS

The fire service is confronted daily with fighting many types of fires which require a variety of types of fire streams, each designed to provide effective control and extinguishment of that particular type of fire. These various types of fire streams can be categorized under the following headings:

- (a) Fog Stream - produces a very fine spray of small droplets of water which can absorb heat rapidly and convert to steam thereby utilizing the maximum extinguishing capacity of the water.
- (b) Solid Stream - produces a solid, unbroken column of water which provides maximum reach and penetration.
- (c) Broken Streams - produce a variety of streams of water to control or extinguish particular types of fires or conditions for which they are designed.

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4. SELECTING THE FIRE STREAM

When a fire company arrives at a fire, the officer should have previously formed a mental impression of certain probabilities and this impression should be based upon the known facts that are available to him through pre-fire planning. A fire usually presents complications and rapidly changing events. A quick survey and analysis should be made and the type of fire stream that will best meet the requirements of the situation should be selected.

Nozzles may be carried attached to hose lines as a unit assembly or as pre-connected lines. In either event, selecting nozzles and streams are a part of pre-fire planning. They are also a result of considerable advance observations. Every member of the company should be aware of the nozzles available, how they are carried, the flow of each nozzle and the correct operating nozzle pressure.

A knowledge of the type of fire is most essential when selecting fire streams for attack because this factor deals with the fuel involved and whether the fire is free burning or smouldering. The state in which a fire is found should govern the type of streams and the position for attack. As the burning process progresses, heat control and fire extinguishment become more difficult because of the magnitude of the fire and the heat that is produced.

In addition to streams to attack the body of the fire, the proper streams must also be selected for the protection of exposures and to secure avenues of possible fire spread.

5. METHODS OF PRODUCING WATER FOG

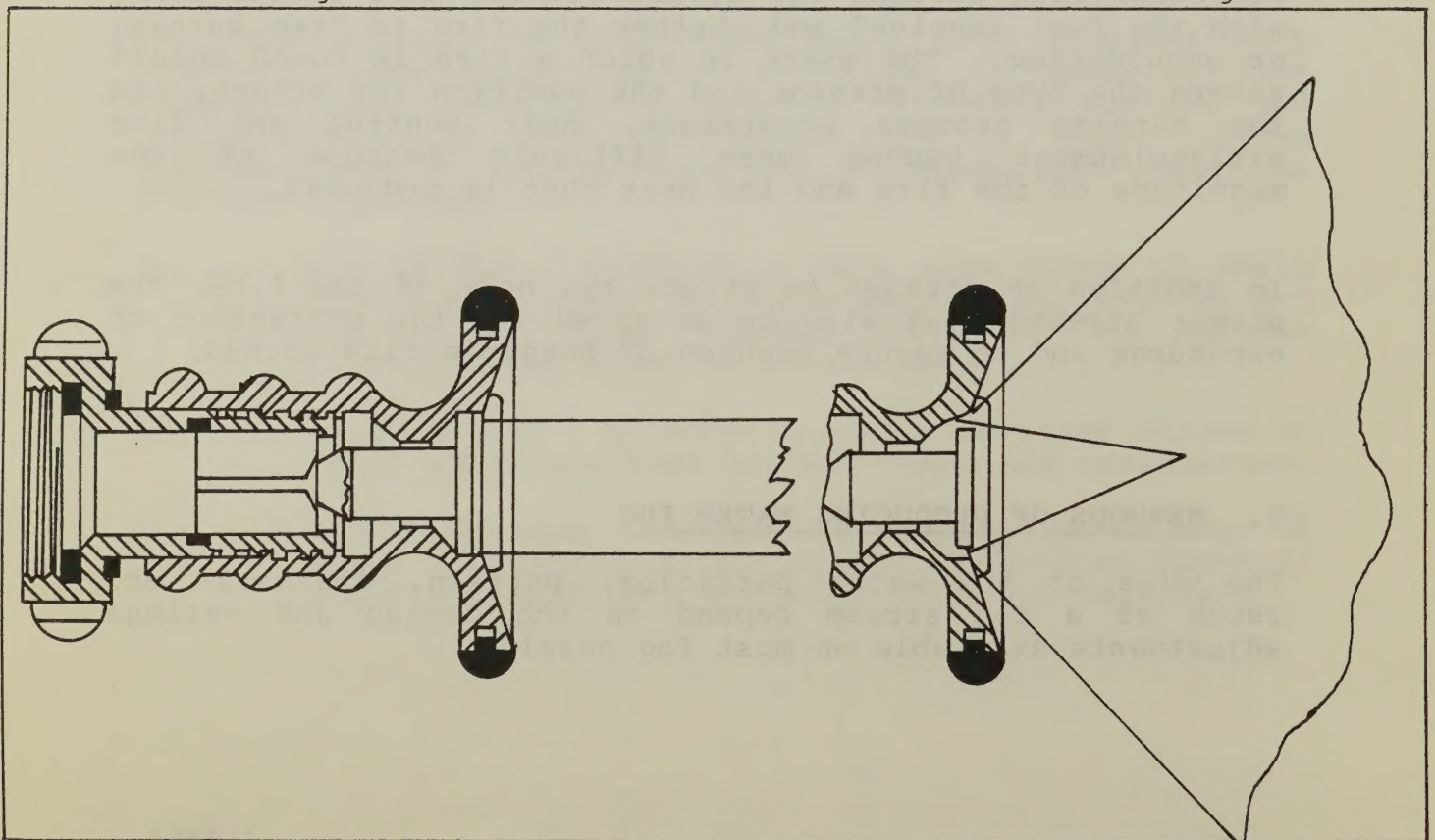
The size of the water particles, pattern, discharge and reach of a fog stream depend on the design and various adjustments available on most fog nozzles.

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Fog streams are produced by forcing the water through one or more mechanical devices which bombard the stream against an obstruction with enough force to shatter the solid mass into finely divided particles. The angle at which the particles are deflected from the obstruction determines the forward velocity and reach of the stream. A wide-angle deflection produces a short-reach fog stream and a narrow-angle deflection produces a long-reach fog stream.

The methods commonly used, either by separately or in combination with one another, to break water into finely divided particles by deflection, are:

- (a) Periphery Deflection - Produces water fog by deflecting the water between a circular deflection stem and the external barrel of the nozzle. It is the most widely used method because it can be adjusted to produce all degrees of patterns from straight stream to wide-angle fog. Nozzles of the periphery deflection type produce a hollow fog cone and the discharge increases as the pattern angle increases on older type nozzles. Modern design features have overcome these two disadvantages.



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NONCONSTANT-GALLONAGE NOZZLES

The pattern of a nonconstant-gallonage nozzle (also called variable-gallonage) is adjustable, and any change in pattern causes a change in gallonage. These nozzles are flow-rated at a narrow setting (about 30°) at 700 KPa base-of-the-nozzle pressure. If the nozzle pressure is held at 700 KPa and the pattern is changed to a straight stream, the gallonage will be reduced approximately 15 percent. If the pattern is changed from 30° to the widest possible pattern, the gallonage will increase approximately 15 percent.

CONSTANT-GALLONAGE NOZZLES

The constant-gallonage nozzle (also referred to as a constant-flow) discharges the same volume per minute whatever the pattern setting. These nozzles usually have three settings: narrow-angle, wide-angle, and straight. As the exterior barrel is rotated to change the pattern, the space between the deflecting stem and the internal throat remains the same, so the same quantity of water will pass through.

ADJUSTABLE-GALLONAGE NOZZLES

The adjustable-gallonage nozzle is a constant-flow nozzle with a refinement: the firefighter at the nozzle can choose from a number of flow settings. This feature allows the firefighter to select the gallonage to suit existing conditions. For instance, if the nozzle pressure is affected for some reason, the nozzleman can adjust the nozzle to compensate. At the same time, the nozzleman should know what flow rate will be personally protective and provide ample gallonage for fire extinguishment.

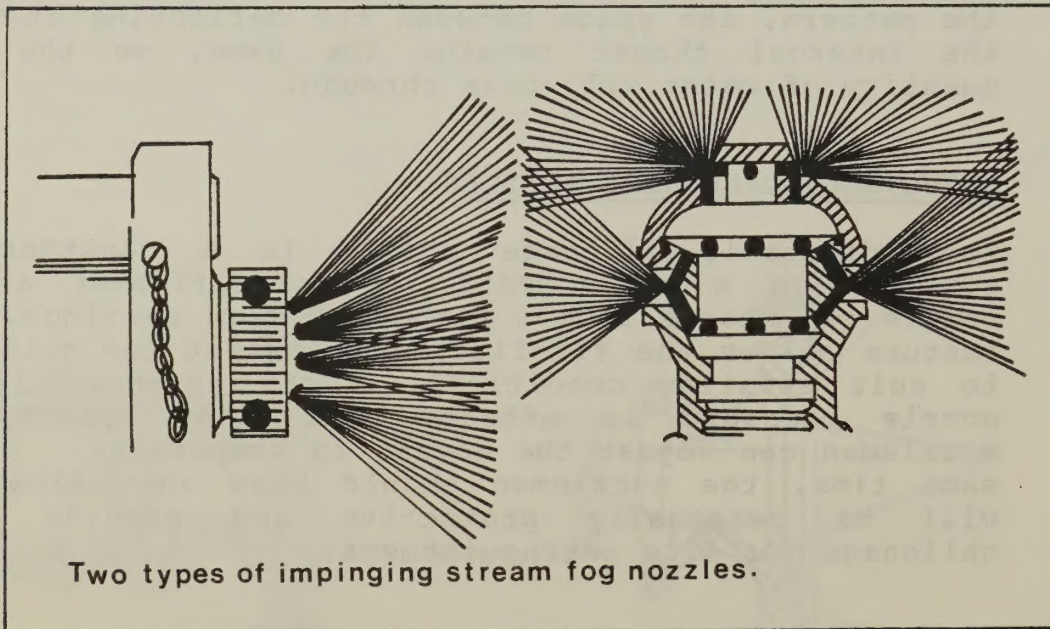
AUTOMATIC NOZZLES

Automatic nozzles (also referred to as a constant-pressure or pressure-regulating) are basically constant-gallonage with pattern change, but not with pressure change. Their primary effect is to maintain

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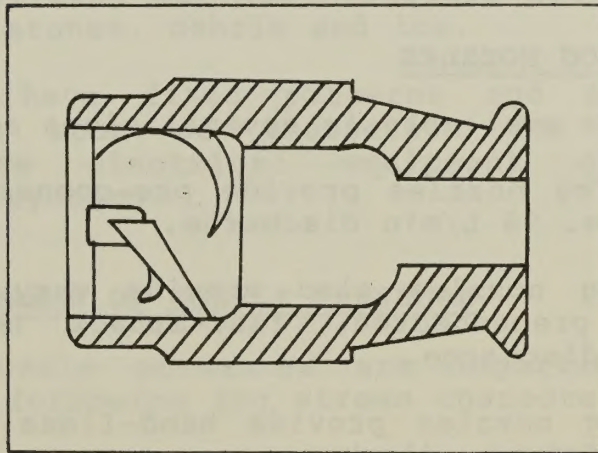
an essentially constant nozzle pressure. If for some reason the gallonage to the nozzle changes, the automatic nozzle will maintain the nozzle pressure and the pattern. This feature is made possible by a baffle that moves automatically, varying the spacing between the baffle and the throat. A stream from an automatic nozzle can look good, but there might not be sufficient water for extinguishment or protection.

- (b) Impinging Deflection - Uses the principle of directing two small jets of water towards each other at varying angles so that they collide and shatter into finely divided particles. Nozzles using this method usually have several pairs of impinging streams and produces a solid cone of fog with no adjustment for varying pattern (fixed pattern).



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- (c) Swirling Deflection - Directs the stream of water at and through spiral blades or vanes causing a rotary deflection and break-up of the stream into finely divided particles. Nozzles using this method can have the spiralling deflection mechanism located internally or externally and usually are of a fixed pattern, although some designs are adjustable.



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Many new nozzles have overcome the hollow cone of periphery deflection nozzles by providing impinging deflection jets in the central stem, thereby filling in the centre of the cone.

Modern, constant discharge nozzles provide an internal sleeve which remains stationary when the pattern is adjusted thereby keeping the size of the opening between the barrel and the stem the same, whether in fog or straight stream position. On many nozzles this internal sleeve has a separate adjustment which provides a variety of discharge selections.

6. SIZES OF FOG NOZZLES

Fog nozzles are available in several sizes as follows:

- (a) Booster fog nozzles provide pre-connected fast attack hose lines. 90 L/min discharge.
- (b) 38 mm fog nozzles also provide very manoeuvrable, preconnected, fast-attack hose lines. 360L/min discharge.
- (c) 65 mm fog nozzles provide hand-lines for larger fires. 750 L/min discharge.
- (d) Master fog nozzles provide mechanically controlled streams for fires where flows of 1800 to 5700 L/min are required.

7. NOZZLE PATTERNS

The most effective fog nozzles for general firefighting are designed to provide varying patterns ranging from straight stream to wide angle fog cones as follows:

- (a) Straight Stream - provides maximum reach and penetration for deep-seated burning.
- (b) 15° to 30° Cones - provide maximum reach in fog form and is most effective in long rooms.

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- (c) 45° to 60° Cones - provide medium reach and coverage and short reach for medium-sized rooms.
- (d) 90° Cones - provide maximum coverage and short reach for small rooms.
- (e) Full Curtain (90° to 150° Cone) - Primarily used as a protective curtain for personnel and exposures.
- (f) Flush Position - Some nozzles are equipped with a flushing mechanism which allows the stem to "pop out", providing maximum clearance around the stem to clear stones, debris and ice.

Some nozzles have fixed patterns and are designed for specific uses such as protection for hazardous areas involving live electrical equipment or in automatic extinguishing systems

8. THE IMPORTANCE OF NOZZLE PRESSURE

Fog stream nozzle pressures are important in that they determine the following fog stream characteristics:

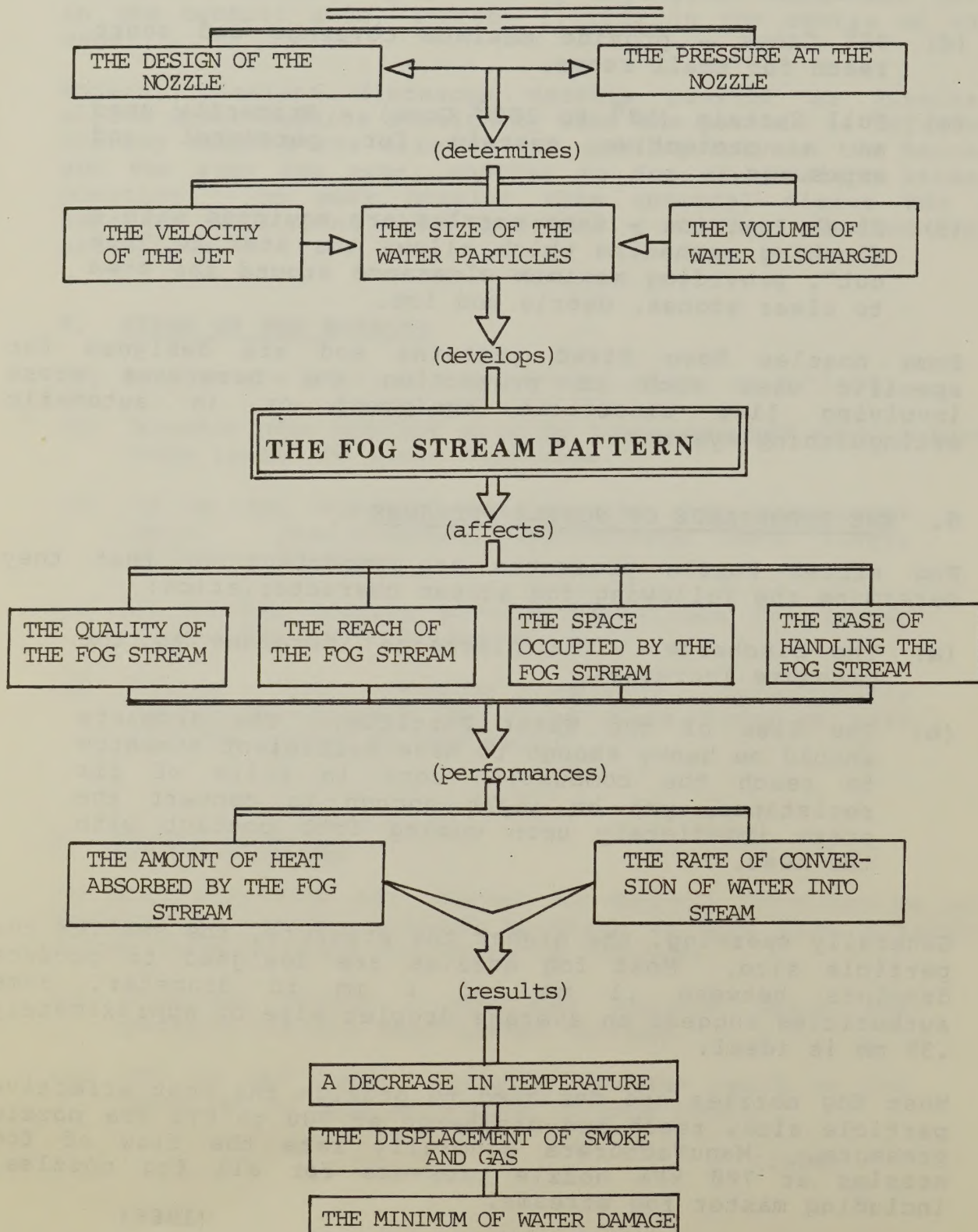
- (a) The Discharge: The discharge increases as the pressure increases.
- (b) The Size of the Water Particle: The droplets should be heavy enough to have sufficient momentum to reach the combustion zone in spite of air resistance, yet be light enough to convert the steam immediately upon coming into contact with the heat.

Generally speaking, the higher the pressure, the smaller the particle size. Most fog nozzles are designed to produce droplets between .1 mm and 1 mm in diameter. Some authorities suggest an average droplet size of approximately .35 mm is ideal.

Most fog nozzles are designed to provide the most effective particle size, reach and discharge at 700 to 875 kPa nozzle pressure. Manufacturers generally rate the flow of fog nozzles at 700 kPa nozzle pressure for all fog nozzles, including master fog streams.

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FACTORS INFLUENCING THE EFFICIENCY OF FOG STREAM NOZZLES



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9. SOLID STREAMS:

Prior to development and widespread acceptance of water fog, solid streams were used as the common method of attack on all types of fires. Today, solid streams are invaluable for providing maximum reach and penetration, which water fog cannot accomplish. Solid streams may also be used after initial fog attack to control and extinguish deep-seated burning.

10. PHYSICAL CHARACTERISTICS OF SOLID STREAMS:

If a fire has reached a considerable magnitude, the quantity of water necessary to have the proper cooling effect becomes very large and, therefore, nozzles must be used which will have a longer reach.

To be effective, the stream of water must be large enough to hold together, have sufficient velocity to overcome gravity and air friction, and be able to penetrate the heat field and strike the burning materials without being vapourized. For all intents and purposes, the fire is literally drowned into submission by the sheer mass of water. When large quantities of combustibles are burning, one large fire stream will be more effective than an equal volume of water from several small streams.

When using a solid stream, an adequate water supply at the fire scene is necessary as efficiency is limited. Probably no more than 10% of the water's cooling capacity is utilized in achieving fire extinguishment.

The extreme limit at which a solid stream can be considered a good fire stream cannot be clearly defined, and is, to a considerable extent, a matter of judgement. It is difficult to say, within two metres or, in some cases even within four metres, exactly where the stream ceased to be good.

The physical characteristics of a good solid stream are considered to be:

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- (a) A stream that at the break-over point has not lost continuity by breaking into showers or spray;
- (b) A stream that would probably be stiff enough to reach the break-over point in fair condition, even though a fresh breeze is blowing;
- (c) A stream that at the break-over point with no wind would enter a room through a window opening and strike the ceiling with enough force to spatter well

SOLID STREAM NOZZLES:

Solid stream nozzles have a waterway of cylindrical shape gradually reducing in diameter from the hose size to the size of the orifice required.

11. BROKEN STREAMS:

The advantages of broken streams is in its use in inaccessible spaces, as a water curtain and is of great importance. Mechanical means of producing broken streams include the following:

- 1. Cellar nozzles
- 2. Partition nozzles
- 3. Sprinkler heads
- 4. Exposure nozzles

It is difficult to draw an exact line between a broken stream and a fog stream except that a fog stream is usually produced in definite patterns and in finer particles.

A broken stream should cover the most space possible and yet afford enough heat absorption to extinguish the fire.

Breaking of the stream at the nozzle is useful when fighting a basement fire through the floor above or when fighting a fire in a partition.

A water curtain is a fire stream which takes, as nearly as possible, the shape of a curtain or fan between a fire and other combustible material. The fundamental requirement of a water curtain is to protect or shield an exposure from fire.

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Tests have indicated that a water curtain between the fire and combustible material is not as effective as the same amount of water flowing over the surface of the combustible material.

12. CAUSES OF DEFECTIVE FIRE STREAMS:

Defective fire streams may be the result of any of the following causes, or a combination of several:

- (a) Untrained Personnel: This is a major cause of defective and ineffective fire streams. Proper training will do much to reduce errors which cause defective fire streams.
- (b) Insufficient Nozzle Pressure: This may be caused by insufficient pump or hydrant pressure, too long a hose lay for the size of hose being used, too large a tip or a combination of all three.
- (c) Excessive Nozzle Pressure: The effectiveness of a fire stream is lost when a high nozzle pressure causes the stream of water to break into a spray shortly after it leaves the tip.
- (d) Bend in Hose Near Nozzle: Any bend in the hose line within 3 metres of the nozzle causes the water to assume a whirling motion. This results in a defective stream as it leaves the nozzle. It is best to utilize a minimum amount of bends, and those very slight in the hose line leading up to the nozzle.
- (e) Wind: The velocity and direction of the wind will affect the distance that a fire stream will travel.
- (f) Obstructions: There are two types of obstructions, internal and external. Internal obstructions result from foreign materials entering the hydrant, pump, hose line or nozzle. They may also be caused by a defective hose lining or protruding gaskets. External obstructions are caused by wires, signs, trees and other objects which might be in the path of the stream of water.

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- (g) Defective Nozzle Shut-Off: When using a nozzle, care should always be taken to avoid twisting or bending the shut-off handle. Either of these conditions may prevent the valve from opening fully or may permit rotation past the full opening. In both instances, the waterway would not be fully open and a broken stream would result.
- (h) Protruding Gasket: A gasket which protrudes into the nozzle waterway will divert a portion of the water. This will cause the fire stream to break up.

13. CARE OF NOZZLES:

Since the nozzle determines the characteristics of the fire stream, it follows that the nozzle must be kept in perfect condition. Any nicks, burns, flat spots, broken or bent deflectors, etc. will impair the quality of the stream. All nozzles should be handled carefully and periodically inspected for damage.

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CHAPTER 11

PART IV

FIRE STREAMS

METHODS OF ATTACK USING WATER FOG

1. INTRODUCTION:

Once the principles and theory of fighting fires with water fog are understood, the actual practice of making a water fog attack can be studied. The success or failure of a fog attack is dependent upon many factors, not the least of which is the fire fighter himself. Numerous fire fighters have been needlessly injured simply because they failed to follow the proper attack techniques. If fire fighters are fully aware of, and follow, the procedures outlined in this note, the chances of a successful attack will be greatly improved.

2. GENERAL ATTACK TECHNIQUES:

(a) Personnel Protection:

Personnel must wear coat collars up, ear flaps down, rubber boots pulled up and the hands must be protected with gloves. Self-contained breathing apparatus must be worn.

(b) Size-up:

The officer in charge must first size up the fire situation confronting him, locate the area of major involvement and make his initial attack at that point. By doubling the volume of the fire area (in metres), the officer can determine the Litres per minute flow rate required and deploy his manpower and equipment to best advantage.

(c) Set the Fog Pattern:

The nozzleman and pump operator must work together to set the pattern, flow rate and nozzle pressure before making the initial attack.

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(d) Initial Attack:

Whenever possible, the initial attack should be made from the inside forcing the fire, smoke, heat and gases from the structure.

(e) Co-ordinate Attack:

Application of water fog at several points simultaneously is generally more effective than from one point; however, officers must co-ordinate the overall attack to ensure that the combined flows are distributed throughout the fire area and discontinued when the fire "blacks out" usually within 10 to 30 seconds.

Control and co-ordination of attack will also protect personnel if the officer ensures that fog is not introduced into the interior while men are working inside or, in multiple line attacks, only one line is allowed to operate at a time otherwise crews may be scalded from expanding steam.

(f) Stay Low:

Interior hose line crews must stay low to keep under the scalding expanding steam.

(g) Application to Upper Room Areas:

Since almost all of the heat is located in the upper levels of a fire area, nozzle men must direct the fog stream into the upper portion of the room with a sweeping or clockwise rotating motion as required by the fire conditions. The pattern can be narrowed after the initial attack to obtain greater reach.

If the fire is in its early stages and has not yet had time to generate sufficient heat in the upper levels, the nozzle man should make a direct application on the burning fuel with a fog pattern or solid stream as required.

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(h) Application in Short Bursts:

The nozzleman should apply the water fog in short bursts of 5 to 10 seconds duration for maximum results, watching for the blackening out effect. Total application should not exceed 30 seconds. If visibility is poor, the nozzleman can listen for the "crackling" of rapid burning as an indication of any free burning fire remaining in the area.

(i) When to Shut Off:

Discontinue application when the blackening out effect occurs which is usually between 10 to 30 seconds total application. The blacking out effect is the condition that results from water fog being converted to steam. Fire Fighters must learn to differentiate between live steam which is a transparent gas and condensing steam which is white water droplets.

(j) Surface Burning and Deep-Seated Burning:

Water fog will usually control only surface burning and cool interior atmosphere. Deep-seated burning should be controlled by direct application and dense materials such as mattresses and upholstery should be removed to the exterior.

(k) Blockage of Air Intake Openings:

Fire fighting personnel must not be allowed to block doorway and window openings while men are working inside. One man crouched in a doorway considerably restricts the inflow of fresh air and greatly increases the interior atmospheric temperatures.

(l) Ventilation:

If the initial application of water fog is successful, the resulting live steam will slowly cool, condense, contract and rise causing an inflow of fresh air from the exterior. This form of natural ventilation usually eliminates the necessity of conventional methods (vertical and horizontal). Conventional methods of ventilation should only be used during the early stages when the fire has not had time to generate sufficient heat or when the initial water fog attack is completed and it is desirable to clear the fire area of the hot, humid atmosphere and improve visibility.

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Directing a fog pattern out of a downwind window will ventilate this area with surprising effectiveness.

(m) Overhaul:

Many fires must be fought a second time due to incomplete overhaul procedures. Thorough overhaul must include the locating and complete extinguishment of all deep-seated burning usually found in dense material, upholstered furniture, behind baseboards and between walls and floors in the lower portion of the room.

Water damage during overhaul must be kept to a minimum as this is when most water damage occurs during water fog fire fighting.

3. DIRECT ATTACK:

The Direct Attack can be defined as a fog or solid stream being applied directly to the burning material. This type of attack is required when the following conditions exist:

- (a) When insufficient heat is present in the upper portion of the room to generate steam. The lack of heat is usually due to the fire being in its early stages or from the heat escaping due to excessive ventilation.
- (b) To extinguish deep-seated burning water fog may be applied directly to the burning material to control surface burning followed by a solid stream to control deep-seated burning.

4. INDIRECT ATTACK:

The Indirect Attack can be defined as a fog pattern being distributed throughout the heated upper portion of a room by a lateral sweeping motion using care to ensure that the pattern does not touch the walls or ceiling. The indirect attack is required when the following conditions exist.

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- (a) When sufficient heat is present to convert most of the water fog to steam.
- (b) When the disruption of the interior atmosphere must be kept to a minimum. This desirable condition is called thermal balance.
- (c) To allow immediate entry by fire fighting personnel to control deep-seated burning or perform rescue, etc.

5. COMBINATION ATTACK:

The combination attack can be defined as a fog pattern being distributed throughout the fire area by a rapid clockwise rotating motion making sure that the pattern comes in contact with the walls, ceiling and fuel with each rotation. The combination attack is required when the following conditions exist:

- (a) When sufficient heat is present to convert most of the water fog to steam.
- (b) When quick control and maximum steam production is required regardless of the disruption of the interior atmosphere (no rescue).

6. CONDITIONS AFFECTING THE SUCCESS OF WATER FOG EXTINGUISHMENT:

Actual fire fighting experience has shown that the principles of water fog application are not always successful on every fire. The most common reasons for failure are the following:

(a) Untrained Nozzlemen:

Probably the most common cause of failure is due to the nozzleman not understanding the principles and practical application of water fog. All members of a fire department should be thoroughly knowledgeable in its use.

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(b) Insufficient Heat:

This condition may be due to the fact that the fire is in its early stages and has not yet had time to generate sufficient heat or the fire may have vented itself allowing a great deal of heat to escape. Fire fighters themselves have often made entry openings too large and too many, thereby releasing heat that is so necessary to the success of water fog extinguishment.

(c) Compartmentation:

Partitions, concealed spaces and lack of windows may prevent fire fighters from applying water fog to the major heat areas. The building layout should be known by proper size-up procedures and by consulting occupants to choose the best point of entry and to ensure that the water fog can be applied to all areas which are heavily involved in fire.

(d) Improper Flow Rate:

If the flow is too small, the fire will be producing more heat than the water can absorb. The small quantity of water may slow down the fire but the building will eventually burn to the ground. If the flow is too much, the generated steam will be quickly condensed back to water thereby releasing the absorbed heat (2250 kJ/Litre) back into the interior atmosphere and seriously limiting the expansion process. The required flow rate for any fire should be determined by the previously described formula for that purpose.

(e) Improper Pattern:

The pattern must be adjusted to suit the type of fire and the size and shape of room. The narrow patterns provide maximum reach in long rooms while the wider patterns are used for short rooms and protective water curtains for personnel and exposures. The solid stream is most useful in providing reach and penetration in deep-seated burning.

(f) Improper Nozzle Pressure:

Most fog nozzles are designed to produce proper water fog at 700 kPa nozzle pressure. The manufacturers flow rate their fog nozzles at 700 kPa nozzle pressure measured at the base of the nozzle.

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If the pressure is too low, the particles will be too large resembling coarse spray and the flow and reach are seriously reduced. Also, the distribution of droplets will be poor thus eliminating the heat absorption and expansion process.

If the pressure is too high, the fog particles will be very fine and light, and may be carried away from the fire by the thermal currents and never penetrate to the fire area.

(g) Improper Co-ordination of Attacking Hose Lines:

Multiple hose lines attack must be co-ordinated so that the required flow is properly distributed throughout the fire area and discontinued when the fire blacks out.

Precautions must be taken that no water fog is introduced into the building from the exterior while men are working inside.

7. ADVANTAGES OBTAINED THROUGH THE USE OF FOG NOZZLES

1. Very rapid heat absorption
2. Quick "black-out" control in majority of situations.
3. Water damage minimized.
4. Steam expansion displaces and disperses smoke and fire gases.
5. Personal protection of fire fighter from radiant heat and firegases.
6. Fog patterns are poor conductors of electricity.

8. DISADVANTAGES OF FOG NOZZLES

The amount of air entrained by a fog stream is far greater than with a straight stream. This can be an advantage or disadvantage depending upon the situation.

About the only time it is advantageous is when advancing in a narrow corridor or stair where the fog can induce a good flow of air from the open doorway behind. At all other times within a structure the low pressure area at the nozzle will attract smoke and heat to that point.

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A serious disadvantage occurs on occasions when the water is not striking the fire, but the air driven ahead of the fog stream fans the fire. This not only happens in rooms but also in ceilings. A fog stream can fan a small fire, in a few seconds when the stream is directed into a hole in the ceiling.

When a fog nozzle is directed through a doorway into a room with no other outlet for the entrained air to escape through, it will force the fire back along the ceiling toward the nozzle, and flames may shoot through the top of the doorway. If the men at the nozzle are standing instead of kneeling, they may get burned.

Another disadvantage of fog occurs when it upsets the thermal balance. Heat from a fire characteristically banks down from the ceiling and it is common for the ceiling temperature to be more than 700°C , higher than the temperature at the floor. This "layering" of the heat enables firefighters to get into the fire area, because a man can endure dry air of about 150°C , without much difficulty. But when fog is applied, the temperature at the ceiling drops to about 90°C , in what is now very moist air, which is above the level of human tolerance. Many firefighters have been burned in this fashion. On many occasions firefighters have been driven out of a building or kept from entering it by this upsetting of the thermal layers.

Bouncing the straight stream off the ceiling does not suddenly change the proportion between heat intensity at the ceiling and floor. The temperature at the ceiling is lowered, without an increase in temperature at the floor, and the atmosphere at the floor remains tolerable because there is less steam there.

(HIGH INTENSITY FIRES - TEMPERATURE AT CEILING EXCEEDS 700°C)

9. USE AND MISUSE OF ELEVATED MASTER STREAMS

To this point, this study has concentrated on the use and handling of nozzles operated from the ground, and has made no reference to elevated master fog streams.

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Use of these appliances is normally restricted to large scale, above-ground fires, but the basic concepts of usage remain the same, water being applied in the right place, form, and quality. Greatest coverage and effectiveness will be achieved when discharge pattern provides maximum horizontal penetration of the fire floor. In order to accomplish this, the nozzle must be at approximately the same height as the fire floor, and operated as close as possible to the opening being used.

These same appliances are sometimes used to create above ground water curtains, at large fires where radiant heat presents serious exposure problems.

In addition, there are occasions where the discharge from the master fog nozzle on the ladder is aimed upwards into the thermal column rising from a large fire, to assist in ventilating, and permit close approach with handlines to the seat of the fire.

For some unexplained reason, an unorthodox practice has crept into fire fighting tactics - directing an elevated stream downwards into a fire from some point above the fire.

THIS PRACTICE IS IN CONTRADICTION TO SCIENTIFIC FIRE CONTROL AND IS A SERIOUS MISUSE OF AN ELEVATED MASTER STREAM.

There is no instance where this method of application can be justified. The physical results will always be the same whenever this practice is employed - natural convection currents, which assist in ventilating the interior of the building, are completely nullified; the heat, smoke and flames are forced to mushroom laterally, making the interior of the building virtually untenable.

Fire fighters attempting to reach the seat of the fire are compelled to retreat or take severe punishment from conditions encountered.

10. THE USE OF WATER FOG AS AN EXTINGUISHING AGENT Structural Fires (Class A)

A fire in the INCIPIENT PHASE will initially have flame temperatures of well over 538°C while room temperatures may be only slightly above normal. The amount of heat being generated will increase as the fire progresses resulting in

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a further rise in the room temperature. The recommended fire fighting procedure is for firefighters to enter wearing positive-pressure self-contained breathing apparatus and apply water directly at the base of the flame.

During the FREE-BURNING PHASE the room temperature will be in the 704°C+ at ceiling level with progressively cooler layers of heat down to floor level where the atmosphere will still be extremely hot, but nothing like at ceiling level. The recommended procedure is for firefighters wearing positive-pressure self-contained breathing apparatus to crawl in and apply just enough water in the form of water fog into the upper atmosphere to reduce the temperature to a bearable level and at the same time produce sufficient steam to smother a major portion of the flames. Extinguishment is completed using direct application.

During the SMOLDERING PHASE the room temperatures remain very high, the flames will have all but disappeared because of the lack of oxygen resulting in large volumes of dense black smoke and highly explosive and very toxic gases. The objective in this case is to prevent backdraft by ventilating above the area followed by immediate application of water fog directed into the upper atmosphere by firefighters wearing positive-pressure self-contained breathing apparatus. The expansion that occurs when the water fog changes into steam, 1600 to 1, helps force the smoke and gases from the area.

Use of Water Fog On Class "B" Fires

Water fog has varying degrees of success in extinguishing flammable liquid fires, depending largely on the characteristics of the fuel involved and the techniques used in applying the water fog.

Some flammable liquids have relatively high flash points, while others have very low flash points.

Water fog is far more effective in extinguishing fuels with high flash points because they can be cooled to a point where vapour production ceases. Low flash point fuels will continue to give off flammable vapours at normal atmospheric temperature, and this makes their extinguishment much more difficult.

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While fog will exert a combined cooling-smothering action on these fuels, it cannot reduce the temperature of the fuel to below its flash point, and re-ignition is likely to occur.

If fire is extinguished, fog application should be continued to ensure that surrounding materials have been cooled to below the ignition temperature of the flammable liquid.

Low velocity fog applicators are best suited to this particular situation, especially when entire burning surface can be enveloped in the fog pattern. When this is not possible, or practical, a narrow fog pattern from a high velocity fog nozzle may be effective for sweeping flames along the liquid surface to a point where they are isolated. This may also be done by co-ordinating several lines, with fog patterns overlapping. Once isolated, dry chemical or foam can be used to complete extinguishment.

Another factor that has to be considered is that all petroleum based fuels and most animal and vegetable oils are insoluble in water and lighter than water.

When attacking these fuels with water fog, any water not converted to steam will sink through the fuel, and the fuel will continue to float on the surface of the water.

If the fuel is in an open container, the application of water can very easily cause the fuel to overflow the container, and this will increase the surface area and severity of the fire.

Medium and heavy oils may be extinguished by playing a narrow angle fog pattern onto the surface of the burning fuel, applied so the fog pattern is almost horizontal to the burning surface. As the water particles strike the surface, they agitate the oil and produce a fire-resistive emulsion which inhibits vapour production. Additionally, the water present in the emulsion absorbs heat from the oil, reducing the oil temperature below its ignition point.

Some flammable liquids, such as alcohol and acetone, are soluble in water, and these liquids can be diluted by the application of water fog. A two-fold action occurs - some of the water is converted into steam by the heat of the fire, and this exerts a combined cooling-smothering action, and in addition, water mixes with the liquid fuel, thereby reducing the volume of flammable vapours given off by the fuel.

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While not actually being used for fire extinguishment, water fog is employed to cool and prevent rupture of flammable liquid storage tanks when they are exposed to fire.

Volumes of water fog are applied to the sides of the tank, above the liquid level.

Use of Water Fog on Class "C" Fires

Control of fires in energized electrical equipment presents an additional hazard of electric shock.

While pure water is a poor conductor of electricity, most water contains mineral salts which do conduct electricity.

Water is very injurious to most electrical appliances and the application of water to electrical equipment should be avoided whenever there is a more suitable means of control.

There may be, however, instances where there is no alternative but to use water, in which case, fog streams should be used exclusively. Fog virtually eliminates the electric shock hazard since water in finely divided form is a very poor conductor.

NOTE: -High Voltage Distance - Keep 5 metres away
-House Voltage Distance- Keep 2 metres away

Use of Water Fog on Class D Fires

Water should not be used for fires in or near combustible metals such as titanium, zirconium, lithium, potassium and sodium. These metals react violently with water when they are involved in a fire. Some of them will react even when there is no fire (potassium and sodium, for instance, release the hydrogen from the water). Most such fires will occur in industrial occupancies, where special extinguishing agents will be readily available. If a combustible metal fire occurs on the highway or railway, the best approach is to protect exposures, making sure that the water does not reach the metal, and allow the fire to burn itself out.

NOTE: FOR ADDITIONAL INFORMATION, REFER TO I.F.S.T.A. MANUAL

(1986)

CHAPTER 12

FIRE PUMPS

1. INTRODUCTION:

Water is the most effective and widely used extinguishant for structural fires for a number of reasons: its ability to absorb heat, its availability, its low cost and its ease of handling. However, seldom is the water found under the exact circumstances which will allow it to be applied directly to the fire. It may be located in a pond, lake or river, or in the watermain under some degree of pressure. If it is to be effective as an extinguishant, it must be applied to the fire in a definite pattern at a predetermined pressure. Since the pressure under which the water is normally found is seldom the pressure needed for effective application, some means of accurately controlling the pressure at which the water will be discharged from the nozzle must be inserted into the delivery system.

This control device is the fire pump and the modern centrifugal pump is capable of increasing pressure to compensate for such things as friction loss, nozzle pressure and loss due to the elevation and in some instances, reduces pressure to compensate for high initial pressure with a high degree of accuracy and dependability. However, to be truly effective, the man controlling the pump, the "pump operator", must fully understand how his pump and its ancillary devices operate and how to use them effectively to ensure maximum efficiency of the fire fighting operation.

2. DRAFTING WATER

Suction may be termed the reverse of pressure, the same as pulling is the reverse of pushing. But the term suction is misleading. The conception of sucking water as the act of pulling or drawing water is erroneous; for to draw or pull an object prescribes the necessity of having some form of connection to it. In the case of sucking up water, what is really done is to reduce the air pressure in an air-tight vessel in direct communication with a source of water supply, by removing the contained air, and thus to enable the atmospheric pressure outside to force the water into the vessel.

Several factors determine the maximum height to which a pumper can lift water by suction. First, the ability of the pump to create a vacuum, which depends upon the tightness of the parts of the pump; next, the air tightness of all connections; third, the atmospheric pressure at the location of the pump is being operated.

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There is a limit to the vertical distance we can draft. If a perfect vacuum could be produced it would be possible to lift water 101.43 (atmospheric pressure at sea level) $\times 0.1\text{m}$ (the height to which 1 kPa pressure will raise water vertically) for a total of 10.143 m or approximately 10 m.

The height of lift decreases with altitude since atmospheric pressure is less than at sea level. The common practice is to use two-thirds of the theoretical height (or 6.66 m at sea level) for the practical limit of draft. This height decreases with altitude about 0.3 m for each 300 m of altitude.

Air leakage may constitute a major reason for loss of suction lift. Even the slightest leak into the pump will make it extremely difficult to exhaust sufficient air from the pump and the suction hose to perform a necessary drafting evolution.

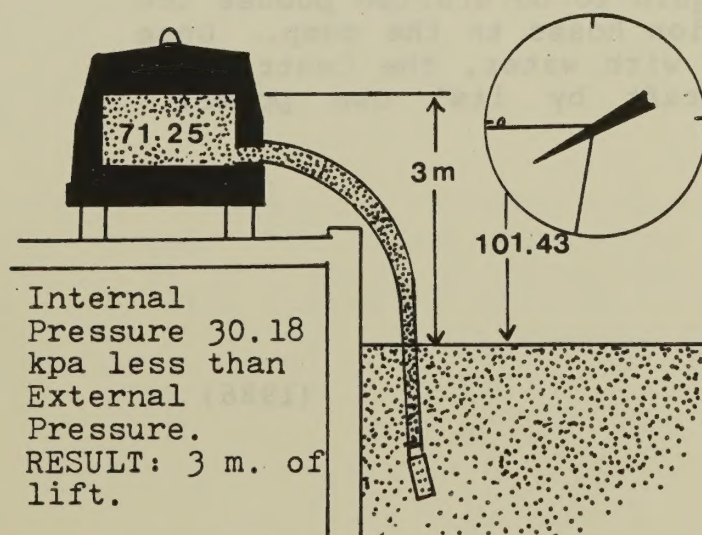
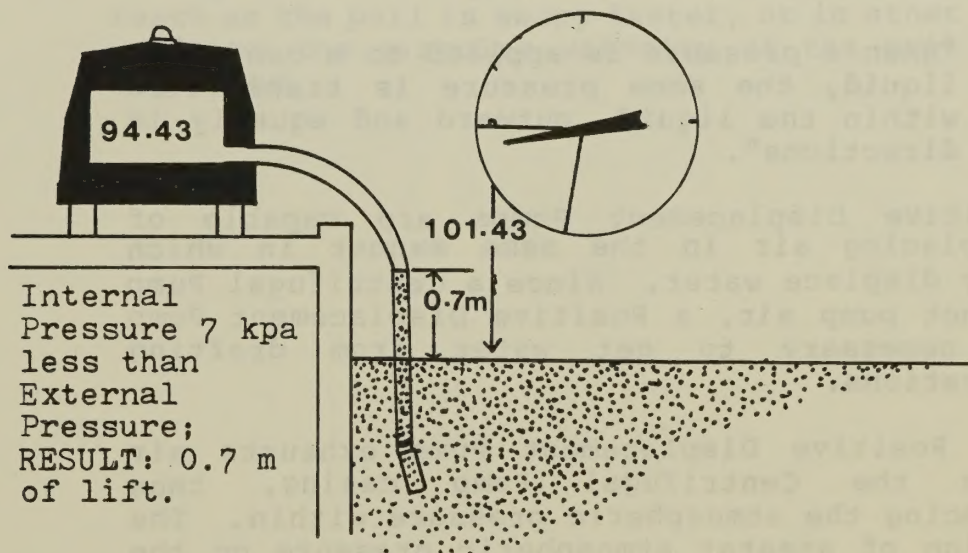
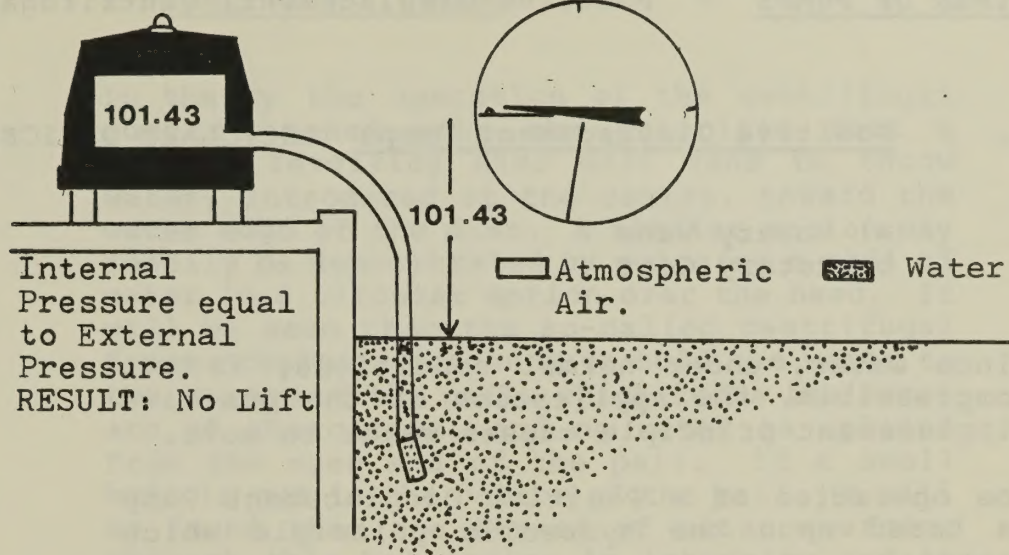
Air leakage, after the pump is primed, will reduce the vacuum in the pump and will cause the pump to lose its prime, if the leak is sufficient. It is therefore extremely important that the gaskets are maintained in good condition and that all the connections are air tight.

Trouble may develop as a result of a clogged strainer which may have become clogged by leaves or other debris being picked up below the surface of the water. An examination of the strainer if symptoms are present, will quickly disclose this condition. A rope attached to the strainer is kept taut to prevent the strainer from touching the bottom of the water and picking up debris. It is important that the strainer be kept clear of the bottom of a body of water, unless there is no danger of it becoming clogged from debris, such as would be the case when pumping from a cistern or any other source having no debris on the bottom. The rope on the strainer will also serve to assist in the placing and removing of the suction during a Hard Suction Hook-up evolution.

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The majority of centrifugal pumps are equipped with a small priming pump of the positive displacement type, or other suitable priming device which creates the necessary vacuum to bring the water up to the centrifugal pump. Once the suction hose and pump housing of a centrifugal pump are filled with water, and the pump placed in operation, it will continue to draft water.

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3. TYPES OF PUMPS - Positive Displacement, Centrifugal

1. Positive Displacement Pumps (ANCILLARY DEVICES)

- a) Rotary Vane
- b) Rotary Gear

Since water, under normal conditions, is not compressible, the application of the positive displacement principle causes water to move.

The operation of a Positive Displacement Pump is based upon the hydraulic principle which states:

"When a pressure is applied to a confined liquid, the same pressure is transmitted within the liquid, outward and equally in directions".

Positive Displacement Pumps are capable of displacing air in the same manner in which they displace water. Since a Centrifugal Pump cannot pump air, a Positive Displacement Pump is necessary to get water from drafting operations.

The Positive Displacement Pump exhausts air from the Centrifugal Pump casing, thus reducing the atmospheric pressure within. The action of greater atmospheric pressure on the surface of the liquid to be drafted pushes the water up the suction hoses to the pump. Once filled completely with water, the Centrifugal Pump can then draft by its' own power.

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2. Centrifugal Pumps

In theory the operation of the centrifugal pump is based upon the principle that a rapidly revolving disc will tend to throw water, introduced at the centre, toward the outer edge of the disc. A similar action may readily be demonstrated by swinging a pail of water in a circular motion over the head. It will be seen that the so-called centrifugal force creates a tendency to hold the water to the bottom of the pail, which forms the outer arc of the circle, and no water is spilled from the open end of the pail. If a small hole is cut in the bottom of the pail, it will be found that the stream of water emerging through this hole gains in intensity and in reach as the pail is swung faster, or in other words as the circular velocity of the pail increases.

Centrifugal pumps are usually classified as single stage, two stage or multi stage according to the number of impellers in the pump to provide stages of pressure increase. Impellers are either single suction type or double suction type.

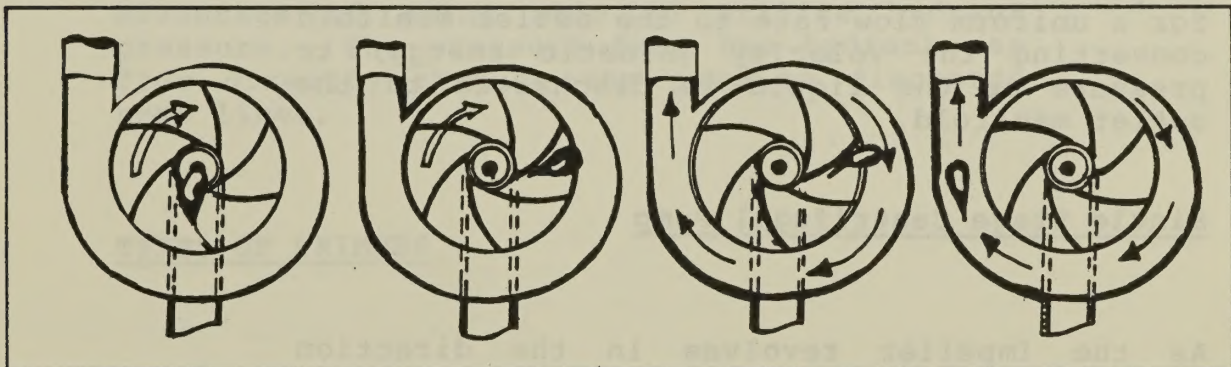
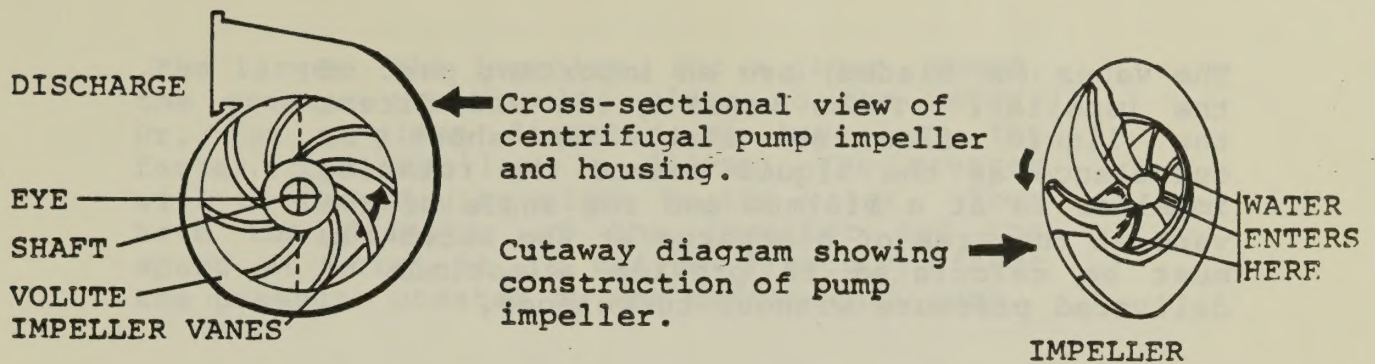
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The centrifugal pump consists basically of one (single stage in use in H.F.D.) or more impellers mounted on a shaft rotating in a housing.

The centrifugal pump is so called from the centrifugal action produced for the discharge of water from the rotating impeller or impellers. The centrifugal pump is a Flow Through type and not a displacement type as the piston or rotary pump. By "Flow Through" we mean, water can freely flow from the pump inlet out the discharge lines without the pump even operating as the passageways are open. This feature of the centrifugal pump has the advantage of fully using the hydrant pressure.

The centrifugal pump impeller is a blade type wheel closed at the sides, with the liquid entering at the eye at the centre or hub. Discharge is at the periphery or outer rim. Liquid directed to the eye or centre of the impeller is picked up by the vanes (blades) in the rotating impeller and discharged by centrifugal force into the collecting chamber of the housing where the pressure and velocity imparted by the rapidly rotating impeller exceeds the pressure and velocity at the entrance eye.

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As liquid is discharged from the impeller a partial vacuum is created at the eye of the impeller and if operating at draft, the atmospheric pressure will force liquid up through the suction hose to replace the water discharged. If operating from a positive pressure source as a hydrant, the liquid under pressure at the suction inlet will supply the pump to replace the liquid being discharged.

Centrifugal pumps are usually classed as single stage, two stage or multi stage according to the number of impellers in the pump to provide stages of pressure increase. Impellers are either single suction type or double suction type.

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The vanes (or blades) are an important part of the impeller. These vanes guide and direct the liquid flow so that the shock or turbulence as the liquid enters the rotating impeller is at a minimum and the angle of the vane at the area of discharge at the outer rim must be calculated to provide a maximum of delivered pressure without turbulence.

Where a wide variation in discharge and pressure requirements prevail, as in the fire service, the volute type of housing is used. This type is the commonly accepted design in all makes of fire pumps in current use. The outlet channel in the housing is volute shaped to provide a uniform increase in channel area for a uniform flow rate to the outlet manifold converting the velocity (Kinetic energy) to pressure as the liquid is discharged to the outlet manifold.

Single Stage Centrifugal Pump

As the impeller revolves in the direction indicated, water introduced through suction tube enters through the centre of the impeller, thrown to the outer edge of the impeller by the centrifugal action and is hurled through openings into the open space in the casing. Since the circumference of the impeller disc is greater at the outer edge of the blade-like vanes than it is at the inner edge of the vanes, the outer edge of the impeller travels at a rate of speed greater than the speed at the inner edge. Thus the velocity of the water passing through the open casing is increased as it passes through the impeller. Likewise as the rate of rotation of the impeller increases, the velocity with which the water is thrown from the eye into the open casing increases.

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The larger the impeller, for a given speed, the greater the impulse given to the water. Or, for a given diameter of impeller, the faster the impeller is driven, the greater will be the impulse given to the water. Thus both the diameter of the impeller and the speed at which it is driven directly affect the pressure created by the centrifugal pump.

The single stage pump consists of one impeller either double or single intake, mounted on a shaft rotating in a housing.

The single stage pump, like all other centrifugal pumps, is a pump that has the advantage of being able to utilize hydrant pressure. The pressure from the hydrant can flow directly through the pump to discharge hose lines.

4. TYPES OF PRIMERS

Most centrifugal pumps require a priming device in order to draft water. To accomplish a draft, it is necessary to create a pressure differential within the pump casing. This is done by creating a partial vacuum within the pump casing, whereby atmospheric pressure on the surface of the water, into which the suction is immersed, is then able to force water up the suction hose to fill the pump casing.

There are several types of priming devices employed on Fire Department pumpers, some are employed individually, others combine two units to make one, for more efficient priming.

Priming devices include:

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1. Rotary Gear Primer - clutch driven.
2. Rotary Vane Primer - electrically driven.
3. Exhaust Manifold Primer (Trailer Pump #14)

1. ROTARY GEAR PRIMER - CLUTCH DRIVE (AIR PRESSURE
ENGAGES CLUTCH)

As the meshing gears of the primer rotate, oil from the reservoir is drawn into the primer for lubrication and sealing. Air is drawn out of the fire pump and is expelled from the primer. As atmospheric pressure forces water into the fire pump, the primer discharge becomes a mixture of oil, air and water.

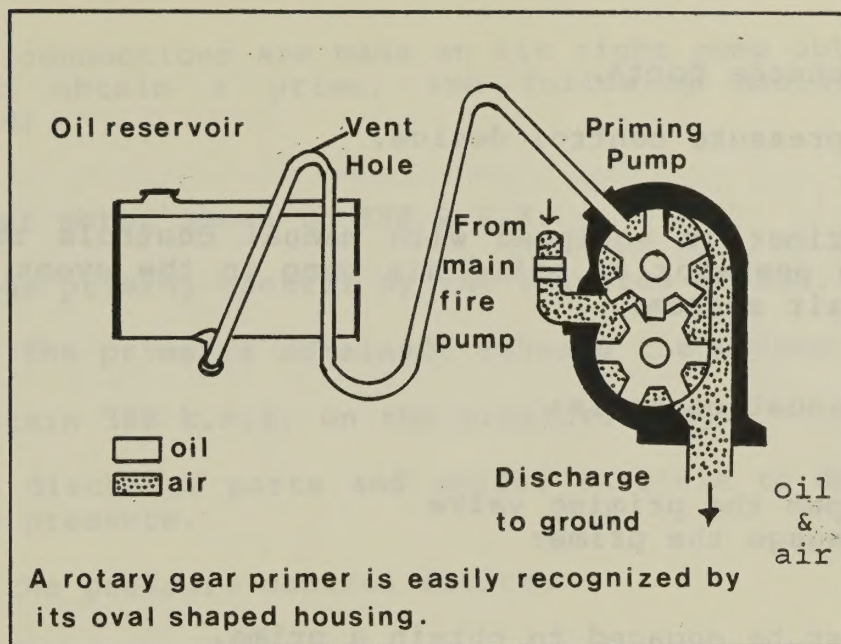
When the pump is fully primed, the primer discharge will be a mixture of oil and water.

The oil reservoir may be above the level of the primer in which case, a siphon action would be established. To prevent the siphoning of oil from the reservoir, a vent hole is drilled in the uppermost loop of the oil pipe. This vent is about 0.5 mm which is a common size for the lead in a mechanical pencil. If the vent hole becomes obstructed, oil will drip from the primer onto the floor until the oil reservoir is empty.

The vent hole should be checked as a regular part of routine maintenance.

A rotary gear primer is easily recognized by its oval shaped housing.

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Rotary Gear - Clutch Driven

Once all connections are made and an air tight pump ensured, the following evolutions are performed to prime the pump.

1. Adjust motor speed to 850 R.P.M.
2. Engage priming device. This will, by air pressure, engage a flat or plate clutch and thereby engage the rotary gear primer.
3. Sealing and lubricating oil is pulled into the primer by a vacuum created within the primer.
4. Once the prime is obtained, release the primer controls.
5. Adjust the throttle to 300 kPa.

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6. Open discharge ports.
7. Set the pressure control device.

This type of primer is equipped with manual controls that will enable the operator to prime his pump in the event of failure of the air system.

There are two manual controls:

1. One to open the priming valve
2. One to engage the primer

Both primers must be engaged to obtain a prime.

2. Rotary Vane Primer - Electrically Driven

As the rotor turns, air is trapped between the sliding vanes. The trapped air is carried to the discharge side where it is forced out by the very narrow clearance between the rotor and the primer housing. The spring loaded vanes slide into slots in the rotor as the space between the rotor and the housing is reduced.

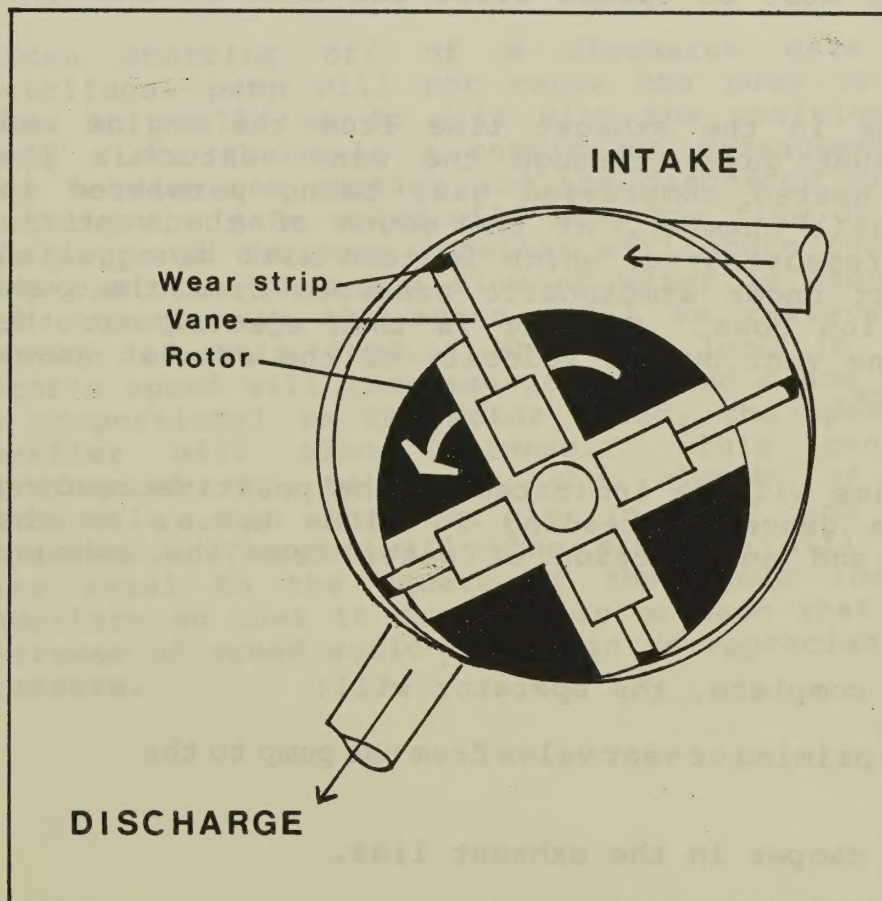
To ensure lubrication and sealing, rotary vane priming systems have an oil reservoir the same as the rotary gear system does.

Rotary vane primers maintain high efficiency over a longer operational life than do rotary gear primers. This is due to the fact that the free sliding vanes are fitted with wear strips on the wearing surface. As the strips wear, the vanes automatically slide further out to maintain a tight seal.

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Once all connections are made an air tight pump obtained, in order to obtain a prime, the following evolutions are performed:

1. Adjust motor speed to 850 R.P.M.
2. Engage priming control by the required method.
3. Once the prime is obtained, release the primer control.
4. Maintain 300 k.P.a. on the pressure gauge.
5. Open discharge ports and adjust throttle to desired pump pressure.
6. Set the pressure control device.



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Exhaust Primer (Trailer Pump #14)

The exhaust primer utilizes the exhaust gas velocity in the exhaust manifold of the gasoline engine. These gases are directed through a device very similar to an ejector. The ejector consists of a venturi valve to which a connection is made from the pump casing. When the control valve is opened, the pressure of the exhaust gases, escaping through the venturi, causes a suction pull in the connection to the pump and eventually the casing, thus priming the pump.

Once all connections are made and an air tight pump ensured, the operator will then engage the priming unit.

If the priming or vent valve is manual, which is often the case, this valve must be opened first and held in the open position.

Close the damper in the exhaust line from the engine and divert the exhaust gases through the cone venturi. The action of the heated compressed gas, being permitted to expand in the bell chamber, at the mouth of the venturi, creates a low pressure area, which in turn will be equalled or filled by air under atmospheric pressure from the pump casing and suction hose. The air is then ejected out the mouth of the cone vent by the velocity of the exhaust gases to the atmosphere.

A successful prime will be indicated by the positive reading on the pressure gauge, a reading in Minus k.P.a. on the compound gauge and an ejection of water from the exhaust primer.

Once a prime is complete, the operator will:

- a) Close the priming or vent valve from the pump to the primer.
- b) Open the damper in the exhaust line.

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- c) Adjust throttle to a minimum of 300 k.P.a. on the pressure gauge.
- d) Open ports and adjust the throttle.
- e) Set the governor.

NOTE: Under no condition should the damper in the exhaust line be closed while high R.P.M. are on the pumping engine as this may result in serious damage to the engine, etc., 1200 to 1500 R.P.M. are safe maximums in most pumps.

5. GOVERNORS AND RELIEF VALVES

Sudden shutting off of a discharge gate valve on a centrifugal pump will not cause the pump to stop nor the motor to stall, as it will with the positive displacement pump, since there is a continuous passageway through the pump between the suction and the discharge side. However, shutting the gate valve will stop the flow of water through the pump and the pump impeller will churn the water in the pump casing. When the flow of water is stopped, the pump and consequently the motor, will be relieved of a great portion of this load. When the load is relieved, the motor's speed will increase greatly and since the pump speed is proportional to the motor speed, the speed of the pump impeller will also increase. This can readily be illustrated by releasing the clutch of an ordinary automobile when the car is in gear and the throttle depressed. Theoretically the pressure will increase at a rate equal to the square of the speed increase of the impellers so that it may readily be seen that even a slight increase of speed would result in an appreciable increase in pressure.

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If such pressure increases were permitted to take place every time a discharge valve were closed, difficulty in handling this speed, and possible danger to the men on the lines might result. Furthermore, a large increase of speed in the pump under appreciable no load would not be beneficial to the pump nor the motor.

For these reasons, a centrifugal pump pressure regulator is provided. Fundamentally, the governor operates in principle along the same lines as a relief valve, in that it may be set to relieve a predetermined pressure, and its operation is actuated by the actual pressure at which the pump is discharging. Common types of governors differ from relief valves, however, in that instead of opening a by-pass between the suction and discharge sides of the pump, they control the setting of the carburetor valve on the motor, thus affecting directly the speed of the motor.

Governors

- 1) Direct Pressure Governor (P#19)

Relief Valves (Found On All In Service Pumps)

- 1) Hale Relief Valve
- 2) Thibault Relief Valve

Direct Pressure Governor (Pump #19)

A pressure setting is applied to the governor by a clockwise rotation of the hand wheel on the governor and removed by a counter clockwise rotation. In this way, a setting is applied directly to the governor mounted on the pump panel.

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Principle Of Operation

The tension exerted on the spring in the main chamber of the governor, that is applied either by direct pressure or remote pressure will control the pump pressure in the following manner

- a) The spring pressure exerts a force on a diaphragm which separates the dry chamber (spring) and the wet chamber (pump pressure). The carburetor butterfly, which permits a gas-air mixture to the engine, is controlled by this spring action, through linkage and lever arms or directly by the action of a moveable rack and pinion gear attached to the carburetor butterfly valve.
- b) Water under pressure from the pump exerted on the wet side of the diaphragm will counteract the spring pressure exerted on the dry side of the diaphragm. Water pressure will close the butterfly valve; spring pressure will tend to open the butterfly, therefore, the greater power or pressure from either side will ultimately control the motor speed and directly control the pump pressure.

It is therefore apparent that if the water pressure increases above the desired pressure set on the governor, this force will push back on the diaphragm, spring and linkage and through this action, reduce the motor speed; and vice versa a decrease in pump pressure on the wet side of the diaphragm will permit the spring pressure to push forward and thus open the butterfly and increase the motor speed, thereby increasing pump pressure. The variations in pressures either above or below the required pressure may be caused by the opening and closing of nozzles or hose line valves, etc.

Operation Of The Governor

1. Set throttle pressure to 70 k.P.a. above the desired pressure.

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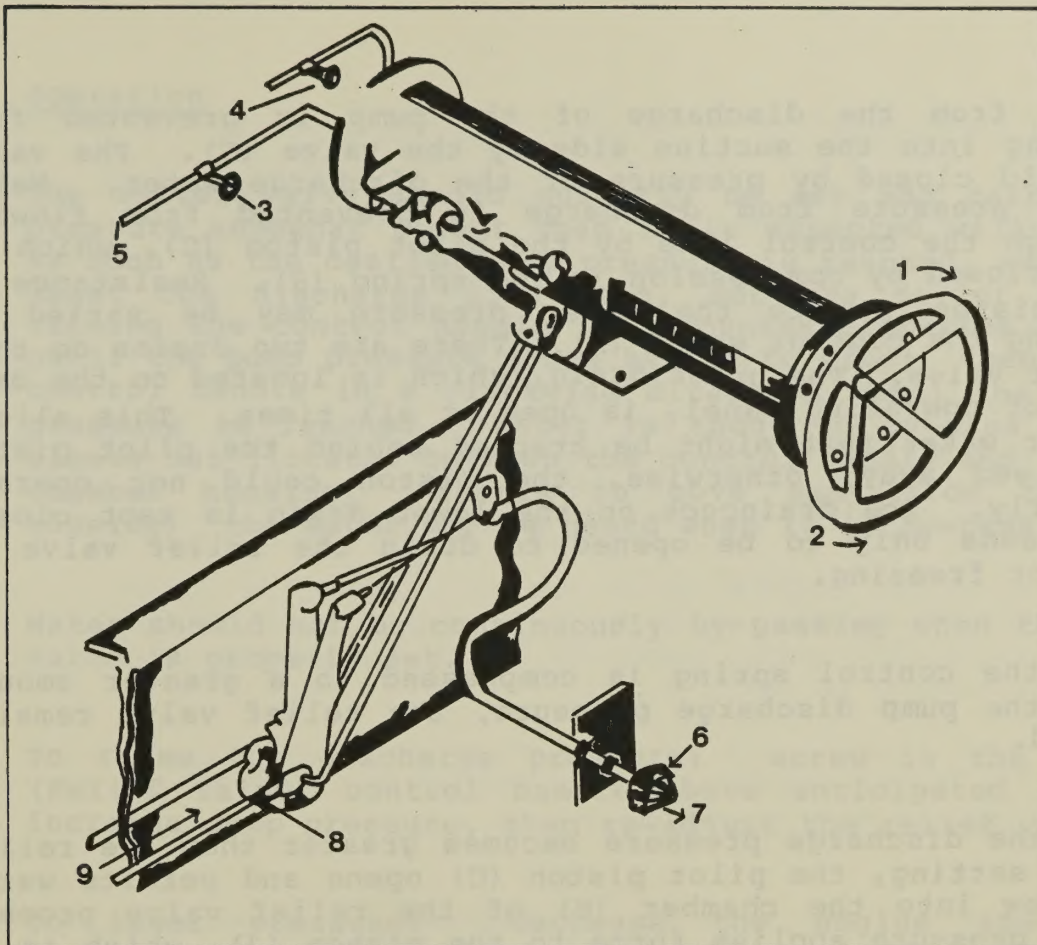
2. Apply pressure or tension to governor spring by clockwise rotation of the hand control wheel to a setting greater than required.
3. Open water control on pump panel to governor, allowing water under pump pressure to enter the wet side of the diaphragm.
4. Turn governor control counter clockwise and reduce the pump pressure until the desired pump pressure is obtained.
5. A governor set in this manner is now controlling motor speed and pump pressure through the governor action. In the event of a malfunction of the governor, motor speed is also controlled to a maximum of 70 k.P.a. above the governor setting by the controlled setting of the throttle.

Vent And Drain Valves

A vent valve is provided on governors of this type to prevent air blockage in the governor on the wet side of the diaphragm. The vent valve should normally be left cracked and thereby, through the passage of a minimum of water to ground, prevent air locks from developing as well as trapping pressure in the governor and controlling acceleration of the engine on return to quarters.

Mack (Hale) pumps are equipped with a governor drain located on the pump panel to enable the governor to drain in freezing weather.

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1. Increase Pressure
2. Decrease Pressure
3. Governor Operating Valve
4. Vent Valve
5. From Pump Discharge
6. Throttle Ground Control
7. To Increase Engine Speed
8. Accelerator Rod
9. Increase

Hale Relief Valve

The Hale relief valve is an automatic churn valve which by-passes water from the discharge side of the pump to the suction side (Figures #1 and #2).

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Water from the discharge of the pump is prevented from flowing into the suction side by the valve (G). The valve is held closed by pressure of the discharge water. Water under pressure from discharge is prevented from flowing through the control line by the pilot piston (C), which is held closed by compression in the spring (S). Resistance of the piston (C) to the water pressure may be varied by turning the control wheel (A). There are two drains on this relief valve. The upper drain, which is located on the back side of operating panel, is open at all times. This allows air or water that might be trapped behind the pilot piston to bleed away; otherwise, the piston could not operate properly. The draincock on the lower drain is kept closed and needs only to be opened to drain the relief valve to prevent freezing.

When the control spring is compressed to a greater amount than the pump discharge pressure, the relief valve remains closed.

When the discharge pressure becomes greater than the relief valve setting, the pilot piston (C) opens and permits water to flow into the chamber (H) of the relief valve proper. Water pressure applies force to the piston (J), which is on the shaft as valve (G) between the discharge and the suction sides of the pump. The same pressure is acting on both the valve (G) and the piston (J) but, as the area of the piston is greater than the area of the valve, the larger total force on the piston forces the valve open and permits bypassing of water in the pump.

When the pump discharge pressure drops below that of the compression pressure of the governor control spring, the pilot piston (C) closed, and pressure against the piston (J) is released through the upper drain. This permits pump pressure in the discharge chamber to close valve (G). Flow between the discharge and the suction sides of the pump is then stopped.

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Operation

The relief valve should normally be set and carried at a pressure somewhat higher than it is expected will be used. As soon as the desired pump pressure is reached, and with at least one discharge line open, set the relief valve by turning the control handle in a counter clockwise direction until the pump pressure gauge begins to drop: then turn the control handle in a clockwise direction until the original pressure is reached. Water is about to by-pass when the sleeve nut (located between the control handle and the upper chamber housing) starts to move away from the valve housing; the water may be heard when it is by-passing.

Water should not be continuously by-passing when the relief valve is properly set.

To raise the discharge pressure: screw in the governor (Relief Valve) control handle above anticipated pressure, increase pump pressure, then re-adjust the relief valve.

To lower pressure: decrease the engine speed, then re-adjust the relief valve.

Maintenance

At least once a month, set the control valve at approximately 1000 k.P.a., and operate the pump at this pressure. Then turn the control handle counter clockwise until pressure drops. The main relief valve is now operating. Turn the control handle clockwise to raise pressure. Repeat this sequence several times to be sure the main relief valve is operating freely.

Relief Valve

A relief valve may be installed in a pump to maintain a uniform pressure and load on the engine during the shutting and re-opening of hose lines during operation. Water

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flowing to nozzles is automatically by-passed to the suction side of the pump when the nozzles are closed, thus preventing the pump pressure from rising more than slightly above the pre-set pressure.

Setting The Relief Valve

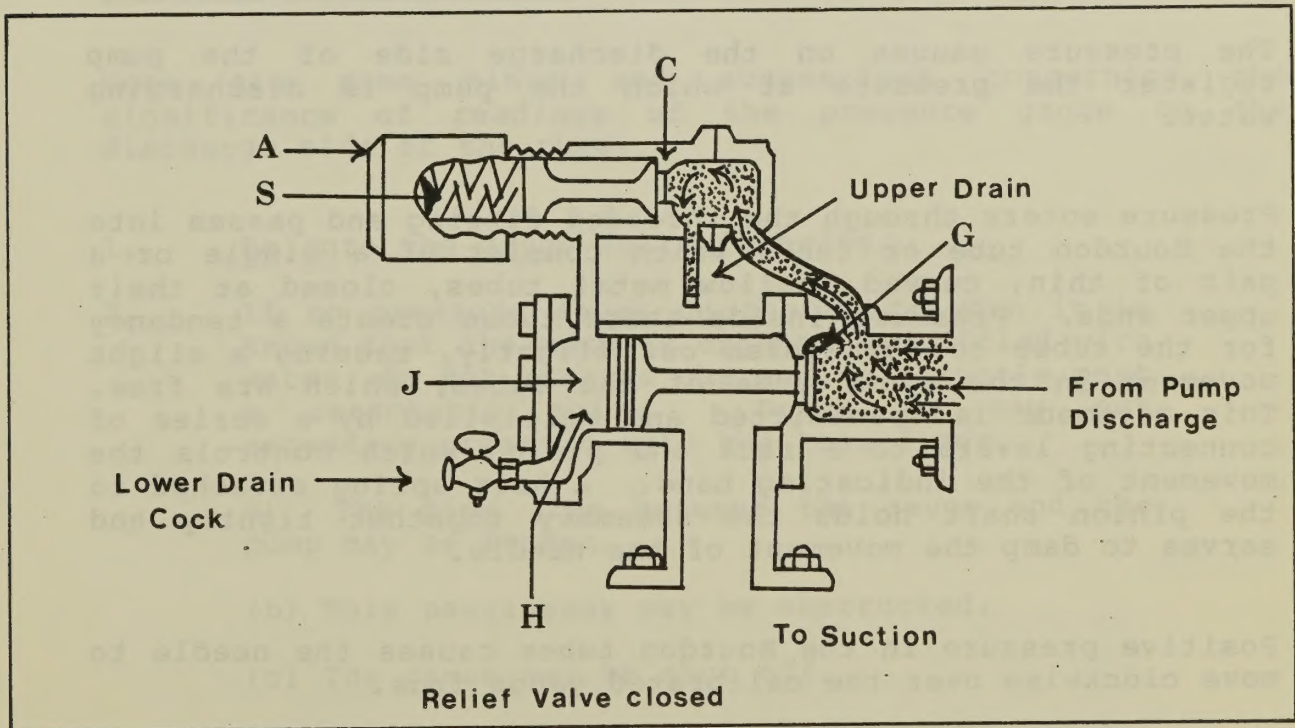
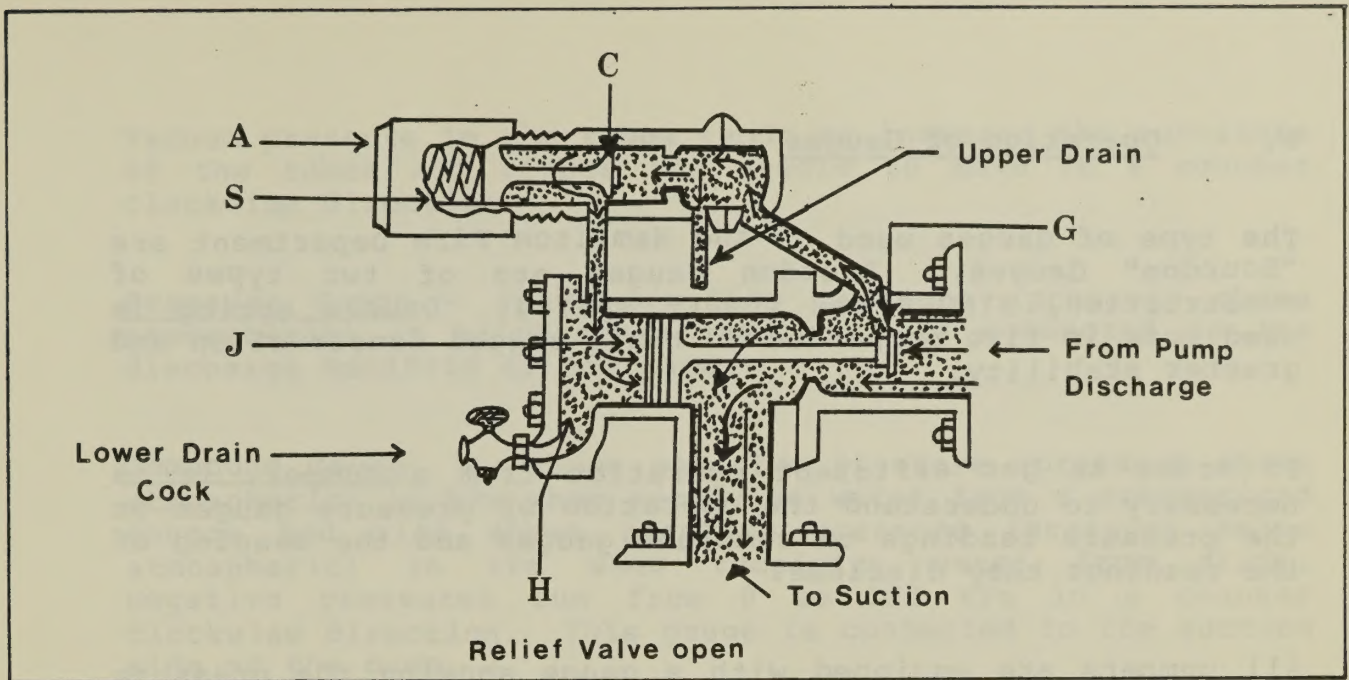
1. Screw adjusting hand wheel in beyond the normal operating pressure.
2. Bring pump pressure up to desired pressure.
3. Wind out relief valve control until the light on the panel goes on. The ignition of the light indicates water is being by-passed from pressure to suction.
4. Turn hand wheel control "IN" slightly, until the light goes out. The relief valve will now operate at the set pressure.

NOTE: A relief valve controls pressure by by-passing undesired pressure to the suction side of the pump, whereas a governor controls engine speed and thereby controlling pressure by the reduction or increase of motor speed through the carburetor control.

Thibault Relief Valve

This operates on the same principle as a Hale Relief Valve. The design is very similar.

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6. Operation of Gauges

The type of gauges used on the Hamilton Fire Department are "Bourdon" Gauges. Bourdon gauges are of two types of construction, SINGLE and DOUBLE spring. Double spring is used more in fire pumps due to their rugged construction and greater stability.

In order to get efficient operation from a pumper, it is necessary to understand the operation of pressure gauges or the pressure readings on compound gauges and the meaning of the readings they disclose.

All pumpers are equipped with a gauge showing the pressure on the suction side of the pump, and gauges to show pressures on the discharge side of the pump.

The pressure gauges on the discharge side of the pump register the pressure at which the pump is discharging water.

Pressure enters through the threaded fitting and passes into the Bourdon tube or tubes which consist of a single or a pair of thin, curved, hollow metal tubes, closed at their upper ends. Pressure inside these tubes create a tendency for the tubes to straighten out slightly, causing a slight movement in the upper ends of the tubes, which are free. This movement is transmitted and multiplied by a series of connecting levers to a rack and pinion which controls the movement of the indicating hand. A hair spring attached to the pinion shaft holds the assembly together tightly and serves to damp the movement of the needle.

Positive pressure in the Bourdon tubes causes the needle to move clockwise over the calibrated gauge face.

(1986)

Vacuum pressure in the tubes tends to increase the curvature of the tubes and causes the needle to move in a counter clockwise direction.

Pressure Gauge - shows positive pressure (pressure above atmospheric) in kiloPascals (kPa) and is connected to the discharge manifold of the pump.

Compound Gauge - shows positive pressure (pressure above atmospheric) in kPa when receiving water from a pressurized source and also shows negative pressure (pressure below atmospheric) in kPa when receiving water from draft. Negative pressures run from 0 to 100 kPa in a counter clockwise direction. This gauge is connected to the suction side of the pump.

Discharge Pressure Gauge

Here are some hints and suggestions concerning the significance of readings of the pressure gauge on the discharge side of the pump.

1. Be sure the gauge is registering.
2. If no pressure shows on the gauge when it is known that the pump is engaged and filled with water, do not advance the engine throttle past a reasonable point. Doing so may put excessive pressure into the hose lines.
 - a) The pipe line between the gauge and the pump may be frozen.
 - (b) This passageway may be obstructed.
 - (c) The gauge may be shut off.
3. Any sudden increase in discharge pressure should be investigated immediately.

(1986)

- a) Perhaps someone has shut off a nozzle.
 - b) There may be a blockage in the line due to the hose being pinched by another pumper or other vehicle, or heavy debris may have fallen on it.
4. Any sudden decrease in discharge pressure should be investigated.
- a) There may be a burst length of hose in the line.

It is considered good practice for the operator to stay within reach of the pump at all times.

Discharge pressure gauges are provided for each hose outlet, it is possible to produce a desired nozzle pressure at two or more nozzles even if the hose lays are of different lengths.

Example

Hose line "A" is 60 metres long and has a 38 mm fog nozzle.
We desire 700 k.P.a. nozzle pressure.

Hose line "B" is 90 metres long and has a 65 mm nozzle.
We desire 700 k.P.a. nozzle pressure.

Answer

For line "A" we require a pump pressure of 1050 k.P.a.
For line "B" we require a pump pressure of 900 k.P.a.

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The pump pressure gauge "A" is brought up to 1050 k.P.a.

The discharge gate controlling line :B: is partly closed until its pressure gauge reads 900 k.P.a. This should give a 700 k.P.a. nozzle pressure on each line.

Suction or Compound Gauge

The gauge on the inlet side or suction side of the pump is a compound gauge that registers either:

1. Pressures below atmospheric pressure, as when drafting, or
Pressures above atmospheric pressure, as when connected to an adequate hydrant supply or hose supply lines from one or more pumpers as in a relay operation.

This gauge tells a very important story concerning the availability of water for the pump.

The pump operator must be able to interpret the meaning of the readings of his suction gauge in terms of how much more can be expected from his pumper and the hydrant or water supply.

Here are some hints and suggestions concerning the significance of readings of the suction or compound gauge on the intake side of the pump.

1. The gauge on the suction side of the pump will show "positive pressure" (pressure above atmospheric pressure) when the supply hose or hydrant is providing water at a rate greater than it is being discharged from the pump.

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When the pump attempts to exceed the supply at the point of intake, the pressure on the suction gauge will fall off below atmospheric pressure. If soft suction hose is being used, it will partially collapse due to atmospheric pressure.

2. When working from a hydrant or other source of water supply under pressure, the pressure shown on the suction gauge should never be allowed to fall below 35 k.P.a. on the gauge. The friction loss in the hydrant and suction hose will be approximately 105 k.P.a. and this, plus the 35 k.P.a. on the gauge, leaves a safe residual pressure in the main of 140 k.P.a.
3. A sudden drop in the pressure reading on the suction gauge should be investigated.
 - a) Other pumpers may have connected to the same main and are using your water supply.
 - b) It may mean a break in the main, or other failure of the water system.
4. When the pump is drafting water, the suction gauge will show less than atmospheric pressure, or vacuum.
5. When drafting water, the vacuum on the suction gauge must be watched closely. A change in the reading will indicate several important possibilities.
 - a) The suction strainers in the pump intake, or on the end of the suction hose, may be clogged.
 - b) The level of the water source may be falling. This means that there is not enough water over the strainer and air may be getting into the strainer. A series of whirlpools or eddies in the water around strainer will indicate whether or not air is being sucked into the strainer.

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7. PUMP PANEL CONTROLS

THROTTLE

A throttle, provides precise control over the engine speed and thereby over the pump pressure.

The vernier throttle has a large knob that is rotated counter clockwise to increase engine speed and clockwise to decrease engine speed. A spring loaded button located in the centre of the throttle knob can be depressed to disengage the screw thread.

In general, the button should only be used for emergency shutdown. The screw consists of a small ball running in a thread. Depressing the button, allows the ball to move up out of the thread. Striking the button may drive the ball across the land between the thread and destroy the screw.

In such cases, the throttle cannot be rotated beyond the damaged portion of the screw. Throttle advancement beyond this point can only be made by depressing the button and pulling out on the throttle. This must be done carefully so as not to create a potentially hazardous pressure surge. Pull the throttle out only far enough to bypass the damaged thread.

When depressing the button for emergency shutdown, place your index and middle fingers behind the throttle knob. Press the button with your thumb and slide the throttle in.

Even under emergency conditions, this procedure should not be performed too quickly. To do so can easily cause severe water hammer that may cause suction lines to burst.

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TANK SUCTION VALVE

The tank suction, tank to pump or water tank valve controls the flow of water from the tank to the pump. This valve is fitted into the large suction pipe between the tank and the suction side of the pump.

When pumps are not fitted with a tank fill valve, the tank suction is used to refill the tank from a hydrant.

Since it is connected to the suction side of the pump, the tank fill valve must not be opened when drafting. In drafting operations, the entire suction side of the pump is under negative pressure. An open or leaking tank suction valve will result in water flow out of the tank.

When the tank is empty, air will enter the pump and cause a loss of prime.

TANK FILL VALVE

The tank fill or pump to tank valve controls the flow of water from the pump to the tank. This valve is fitted into a pipe between the discharge side of the pump and the tank. Use this valve to fill the tank from a hydrant or to top up while drafting.

DISCHARGE VALVES

Discharge valves are provided for each discharge outlet. These valves control the volume and pressure to each hose line.

Discharge valve operation may be by means of a pull rod or by means of a swinging lever. The swing lever type may move vertically, horizontally or diagonally.

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Locking devices may be fitted to the valve handle. Locks should be engaged only on partially open valves to ensure that the valve setting does not change due to vibration or water flow.

Valves that are controlling water must be opened or closed slowly in order to prevent dangerous pressure surges. The higher the pressure difference across a valve, the greater the danger of causing dangerous pressure surges.

Valves that do not have any pressure differential across them can be opened or closed quickly and without any danger. Several such cases are, the tank suction valve, preconnected 38 mm lines when operating off the tank and pump pressure is not yet increased or any pressurized line on which the nozzle is closed.

In general, any valve that will change the velocity of the water flow, must be operated with care.

AUXILIARY COOLER

All pump panels have a valve to control the auxiliary cooler. The purpose of the cooler is to correct engine overheating without diluting the engine coolant.

The auxiliary cooler should be opened ONLY if the engine begins to overheat. Premature opening of the auxiliary cooler will prevent the engine reaching its proper operating temperature. This condition increases engine wear and causes excessive carbon buildup.

The auxiliary cooler consists of a small diameter copper tube that is connected between the discharge and suction manifolds of the pump. The tube flows through a heat exchanger where hot engine coolant gives up heat to the cold water flowing through the tube.

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PUMP BYPASS VALVE

The purpose of the system is to provide a small but constant flow of water to prevent the pump from overheating.

A small line allows water to flow from the pump discharge through the valve to the water tank. When the water tank is full, the water runs out the overflow onto the ground.

DRAINS

All pumps have a large number of drains. Some of these are situated in locations that are only accessible from underneath the truck. Others are controlled from a central control on the pump panel. All pumps have some drains that can only be reached from underneath the truck.

Drains are located at the lowest points of the pump, valves and pipes. It is in these same low spots, that sediment or debris will collect.

For this reason, all drains should be opened periodically. They should be allowed to flow until the drainage is clear. To ensure proper flushing, open the drain valve or petcock fully.

8. OPERATING THE PUMP - GENERAL PROCEDURES

The following operations are performed in the cab of the pump.

1. Spot the pump in the proper location with a water supply available.
2. Set the hand brake or Parking Brakes (air).

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3. Apply the micro brake - if equipped.
4. Place transmission in neutral. Shift the Road to Pump Control (Lock if equipped).
5. Place the pump transmission in the proper gear.
6. Lock the gear shift lever in place.

NOTE:

When the transmission is shifted from road to pump the inner workings are as follows:

- 1) Power from the front drive shaft is removed from the rear wheels by a sliding gear and transferred to the pump drive gear. This now drives the impeller
- 2) Power is locked out from rear wheels and the pump is now being driven by the engine.

Operation At The Panel

1. Open all ports supplying hose lines.
2. Increase the throttle to desired pump pressure.
3. Set relief valve.
4. If engine temperature rises above 82 degrees C., open engine cooler.

Power Requirements

The discharge of each litre of water under pressure represents a definite amount in the way of power requirement. For a given flow, as the pressure increases, more power will be needed. Or, if the pressure is maintained constant and an increased discharge is produced, additional power is needed. Neglecting the factors of friction loss

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and pump efficiency, the hydraulic power output of the pump will be equal to the power input of the driving unit. Thus there is a very definite limit to the amount of discharge or pressure produced by a fire pump by the use of a motor of a given size.

The discharge can be increased materially by reducing the discharge pressure, but there is a point beyond which further increase is inadvisable. As the load on the motor is lessened by reducing the discharge pressure of the pump, the motor can be speeded up to give a higher discharge of pump. However, there is a safe maximum speed of the motor which should not be exceeded. Thus it would not be possible to increase the discharge indefinitely by lowering the discharge pressure and increasing the R.P.M. of the pump and engine.

9. CAVITATION IN FIRE PUMPS

In any fire pump, pronounced cavitation can be destructive. Pump operators should, therefore, study the principles of cavitation and learn to recognize when a pump is cavitating.

If the pressure at any point inside a pump drops below the vapour pressure corresponding to the temperature of the liquid the liquid will vaporize and form cavities of vapor. Vapor bubbles are carried along with the stream until a region of higher pressure is reached, at which point they collapse or implode with a tremendous shock on adjacent walls. This phenomenon is called cavitation.

Cause of Cavitation

Cavitation is caused by reducing the absolute pressure on water below the boiling point. It occurs at the point of lowest pressure - that is, highest vacuum, which is usually

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at the impeller eye in back of the leading edge of the impeller blade. When a pump is cavitating, water in the fire pump suction flashes into steam, or water vapor, which is the same thing. Bubbles of water vapour as the mixture flows through the impeller there is a rapid, almost instantaneous change from a vacuum to substantial pressure. Vapor instantly condenses under the higher pressure and water rushes in at high velocity to fill the void. Suddenly the bubble is full, and the inertia of the water produces an intense shock. This shock strikes walls surrounding the water with a forceful impact and can cause severe damage to the metal.

Conditions Creating Cavitation

Conditions Creating Cavitation are: pressure is reduced (and conversely vacuum is increased) on water within the suction on the pump by:

- a) Excessive lift.
- b) Too small or too long a suction hose.
- c) A blocked or inadequate suction strainer.
- d) Pumping abnormally warm water.
- e) Low atmospheric pressure (high altitude)
- f) Pulling a high vacuum on a small water main.
- g) Combination of any of the above causes.

Operate To Avoid Cavitation

A reliable way to determine the cavitation point of a fire apparatus pump under any suction condition is to open the throttle gradually (while watching the engine tachometer and pressure gauge, AN INCREASE IN ENGINE R.P.M. WITHOUT A CORRESPONDING INCREASE IN PRESSURE INDICATES CAVITATION.)

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When this condition occurs, nothing is to be gained by running at a higher R.P.M. Cavitation will become more severe and no more water will be put on the fire. The pump is said to be "running away from the water".

Most compound gauges are difficult to read and are often inaccurate on the vacuum scale. Experienced operators can judge when the pump is approaching cavitation by watching the compound gauge. A better way is to note the one point at which speed increases without an increase in pressure, also abnormal sounds coming from the pump itself.

Hard suction hose (noncollapsible under vacuum) must be used when pumping from draft. Soft suction has an advantage when pumping from hydrants. Fire pumps occasionally have the capacity to pump more water than a hydrant outlet will supply. Under this condition, the pump can cavitate. Soft suction will collapse under vacuum and will thus indicate that the hydrant can supply no more water, and that the pump is cavitating or is approaching cavitation. The pump operator MUST watch the compound gauge and not let it fall below 35 k.P.a. as the suction is of a non-collapsible type, therefore there is no physical sign that the cavitation is taking place.

CAVITATION WHEN PUMPING FROM A HYDRANT IS NOT UNCOMMON!

Cavitation is usually more severe at high pump pressures than at low pressure. Remember that cavitation will gradually damage a fire pump. To avoid cavitation, engine and pump speed should not be increased beyond that speed at which pump pressure ceases to rise.

10. REVIEW OF FACTS TO BE CONSIDERED WHEN PRODUCING FIRE STREAMS

From our discussion we have learned that there are certain basic facts that the pump operator must keep in mind when he is called upon to produce a fire stream of a given volume at a required pressure.

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1. He must know the length of hose in the layout, and the diameter of the same (38 mm, 65 mm, etc.)
2. He must know the type of nozzle in use. (fog or open tip.)
3. He must know the diameter of the nozzle opening.
4. He should know the reach of the stream at a given nozzle pressure and the reaction of the same.
5. He must keep nozzle pressures within safe working limits especially when men are working from ladders.
6. If the nozzle is to be raised above the level of the pump, he must know how high, and add sufficient pressure to overcome the gravity pressure (10 k.P.a. per 1 m of height).
7. There is a limit to the height to which we can draft water. If there is a choice, keep the lift as low as possible. The maximum lift should not be expected to be more than 4.5 to 6 metres.
8. Friction loss is always figured per 30 metres of hose.
9. Remember that the air has to be taken out of the suction hose before water will rise in it. For this reason, keep the suction line as short as possible.
10. The operator should know the approximate L./min. that is being delivered.
11. He should know the capacity of his pump and stay within its limits.
12. He should get to know the accessories on his pump and learn what they are for and how to use them. This means the primer, the gauges, the pressure relief valve.

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13. Don't be "Throttle--Happy". A 1400 k.P.a. pressure doesn't necessarily mean that you are doing a good job.

11. CAPACITY OF FIRE PUMPERS

It is necessary for the operator to know the capacity and classification of his pumper.

Class "A" Pumper

Pumpers in this classification will deliver as indicated below:

100% of the rated capacity at 1000 k.P.a. net pressure.

70% of the rated capacity at 1350 k.P.a. net pressure.

50% of the rated capacity at 1700 k.P.a. net pressure.

Thus we can expect the following delivery from a Class "A" 5000 L/Min pumper:

5000 L/Min at 1000 k.P.a.

3500 L/Min at 1350 k.P.a.

2500 L/Min at 1700 k.P.a.

We can see from the foregoing how the volume delivery of the pump is lowered as we get into the higher Pressures.

12. PUMP TESTS

Acceptance Test - Underwriters (3 hours)

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<u>Pressure Class "A"</u>	<u>% of Capacity Class "A"</u>	<u>% of RPM not to be exceeded</u>	<u>Length of Time Tested</u>
1000 kPa	100	80	2 hrs.
1350 kPa	70	90	1/2 hr.
1700 kPa	50	90	1/2 hr.

Endurance Test - Underwriters or Manufacturers (12 hours)

Same as above, except the length of time test which is:

6 hours - instead of 2 hours

3 hours - instead of 1/2 hour

3 hours - instead of 1/2 hour

Service Test (50 minutes)

This test is conducted by our own department, under the direction of the Master Mechanic once a year or when the motor has been overhauled. It is the same test as the acceptance or endurance tests, with the exception of the length of time tested, which is as follows:

30 minutes

10 minutes

10 minutes

The above tests are conducted from draft using 6 metres (2 lengths) of hard suction.

From draft, a pump must be able to lift its rated capacity at least 3 metres.

A short overload test shall be conducted to demonstrate the ability of the engine to develop 10% excess power. This test shall consist of a discharge rated pump capacity at 1100 kPa, net pump pressure.

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13. CARING FOR A PUMPER

A good pump operator should see that his pump is given proper care and is always ready to respond to an alarm.

While operating at a fire the operator should stay with his pump at all times, paying particular attention to all gauges, etc., and upon returning to the station certain other duties should be performed.

Caring For a Pumper at A Fire

- Ammeter - notice this occasionally to see if the generator is charging.
- Oil Pressure Gauge - see that pressure is maintained - add oil if necessary.
- Diesel Fuel - check frequently during a long operation.
- If the engine has a dual ignition see that both switches are on.
- Temperature - keep the temperature of the water in the radiator at normal (approx. 82 degrees C.). If the engine is overheating utilize the auxiliary cooler to maintain normal operating temperature. The operator must be constantly alert to any overheating within the pumping unit. Overheating may develop due to lines being closed with no release of water from within the pump. The energy being developed is converted to heat and creates a damaging overheating condition. This may be relieved by by-passing water to ground and permitting cool water to enter the pump; if the pump cannot be shut down or lines opened. If the pumper is being operated, delivering water from the tank without a hydrant supply, the tank to pump and pump to tank line may be opened to permit the water to circulate within the pumping unit and thereby maintain a cool pump.

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Care For a Pumper At a Fire In Cold Weather

1. Keep engine running when out of quarters.
2. When a pump is not in operation at a fire, the 25 mm line must be cracked into the tank and the pump put into operation to circulate the water.
3. When pump is in operation hose lines should be cracked and port covers loosened off.
4. Leave bleeder valve in feeder lines to mounted deluge sets open and keep a bung plug in 65 mm intake so clapper valve is open when not in use.
5. Tarps can be hung over pump panel to confine heat.

Caring For A Pumper Upon Return To Station

1. See that the ignition switch/s are turned off.
2. Fill the booster tank.
3. Fill the Fuel Tank.
4. Check the radiator.
5. Check oil in priming device; add if necessary.
6. Inspect the tires.
7. See that clean, dry hose has replaced the wet and dirty hose.
8. Clean the apparatus.
9. In the event that the pump has been run dry, or that the suction cap has been removed, refill the pump by use of the primers to avoid a vacuum in the pump casing.

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A routine check of the pump will assure its readiness to respond to a fire. This should be done immediately after the change of shift.

Daily Routine Check

1. Fuel - check to see that the tank is full.
2. Oil - when the test stick shows below "FULL" add a good grade of oil.
3. Radiator - check level and add anti freeze if necessary.
4. Tires - check the air pressure with tire gauge. Watch for defects, visible cuts or breaks.
5. During daily routine check and at every fire, operate control valves and governing devices to prevent sticking.
6. Check the lights to see that they are in proper working order.
7. Check water level in the booster tank; add if necessary.

Possible Troubles - Causes - and Remedies

While it is impossible to list all the possible troubles; a few are given which may be helpful to the operator. One thing is absolutely certain - there will be less trouble if the pumper is properly cared for and the operator learns to do things correctly.

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Troubles

Causes and Remedies

Engine fails to start

1. See that ignition switches are "ON".
2. Is the battery charged?

Can't get pump in gear

1. Perhaps the engine is running too fast.

Unable to get prime

1. Check pump and suction hose to to see:
 - a) Cap on opposite side is on tight.
 - b) Suction hose is tight at pump and between sections. Check gaskets.
 - c) Suction hose in water.
 - d) Discharge gates are closed on centrifugal pump.
 - e) See that relief valve, booster line valve and valve to radiator are closed.
 - f) Have proper speed for engine with specific type primer.
2. Perhaps the lift is too high.
3. Check to see if there is oil in priming device.

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Pump primed then
prime lost

1. Check for clogged suction screen.
2. May have allowed pump pressure to be too low when nozzle was closed then reopened.
3. Air leak at suction joints.
4. Suction hose not deep enough in water.
5. Discharge gates opened too fast.

Water supply lost

1. If from hydrant, you may be trying to take more than the main will supply. Never permit intake gauge to drop below 35 k. P. a.
2. Eddies formed because water is not deep enough over suction hose. Lower suction in water if possible.
3. Suction hose strainer plugged with mud and debris. Try to keep at least 30 cm from bottom.

Engine racing

1. Burst section of hose.
2. You may be out of water.

Can't build up pressure

1. Pressure regulator without proper tension.
2. You may be attempting too large a volume of water for the pump.

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3. Transmission is not in proper gear.

4. Air in pump.

NOTE: FOR ADDITIONAL INFORMATION REFER TO I.F.S.T.A.
MANUAL.

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2. Administration is not in order.
3. 1992.

4. All in order.

5. 1992.

6. 1992.

7. 1992.

8. 1992.

9. 1992.

10. 1992.

11. 1992.

12. 1992.

13. 1992.

14. 1992.

15. 1992.

16. 1992.

17. 1992.

18. 1992.

19. 1992.

20. 1992.

DECLARATION

Page

A. INTRODUCTION

1. PURPOSE AND SCOPE

1. The purpose of this declaration is to state the truth and accuracy of the information provided in this document.
2. It is hereby declared that the information provided in this document is true and accurate to the best of the knowledge and belief of the declarant.

2. VERIFICATION OF INFORMATION

1. The declarant has taken reasonable steps to verify the accuracy of the information provided in this document.
2. The declarant has taken reasonable steps to ensure that the information provided in this document is true and accurate to the best of the knowledge and belief of the declarant.
3. The declarant has taken reasonable steps to ensure that the information provided in this document is true and accurate to the best of the knowledge and belief of the declarant.

3. SIGNATURE AND DATE

Signature of Declarant: _____
Date: _____

CHAPTER 13

FOAM

1. INTRODUCTION

PRIMARY IMPORTANCE

1. Its ability to extinguish fires for which water alone is inadequate (class B fire).
2. As is known water will sink below the surface of hydrocarbons such as gasoline and oil, and will mix with "polar solvents" such as alcohol and acetone. Foams, however, will float on the surface of flammable liquids.

Effects Of Foam On Fire

1. Smothering: Preventing the marriage of air and flammable vapors.
2. Suppressing: Preventing release of flammable vapours.
3. Separating: Intervening between the fuel and the fire.
4. Cooling: The foam's water content helps to lower the temperature of the fuel and adjacent surfaces.

2. MECHANICAL FOAM:

Mechanical foam is subdivided into two types of foam. Low expansion foam - used mainly for Class "B" liquid fires. Low

High expansion foam - used generally on Class "A" confined fires and Class "B" spills.

Mechanical foam is produced by introducing air into an aqueous solution containing a relatively small percentage of foam forming concentrate. The quality of the foam product, its density and consistency is dependent on the equipment used, with expansion ratios reaching up to 1000:1. Mechanical foam is always produced with liquid concentrate inducted into the water stream before coming into contact with air to form the foam. The turbulence or swirling effect of water as it moves along the hose line is the mixing action required to blend the concentrate evenly with the water. There are several types of foam concentrates available and are generally classified as protein mechanical or synthetic mechanical.

Protein Mechanical Foam

This foam contains animal or vegetable protein, plus metallic salts to give strength to the foam bubbles in the presence of heat and mechanical action. One example is Protein 6%.

Synthetic Mechanical Foam

Synthetic Mechanical foam concentrates are based on detergents and additives, and include Hi-ex, A.F.F.F. and alcohol-resistant AFFF/ATC).

3. FOAM CONCENTRATES USED BY THE HAMILTON FIRE DEPARTMENT.

(A) Regular Protein 6%

Regular protein foam utilizes hydrolyzed liquid concentrates that have high molecular-weight natural protein polymers derived from natural protein solids (animal hoof, horn,

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bone, blood). The polymers give elasticity, mechanical strength, water retention and high heat resistance to the foams generated from them. These concentrates also contain polyvalent metallic salts that aid the natural protein polymers in their bubble-strengthening capabilities when foam is exposed to heat and flame. Organic solvents are added to the concentrates to improve their uniformity as well as to control viscosity at low temperatures. These protein-type concentrates produce dense, viscous foam with high stability, heat resistance and better burnback resistance. Their adhesiveness gives them the ability to cover vertical surfaces which helps to cool tank walls and their stiffness gives greater range.

Regular protein foams are easily contaminated by fuel. Plunging the foam during application should be avoided, as this method causes the foam to sink below the fuel, rise to the top of the fuel, become contaminated with the fuel and, possibly, be easily reignited. Gentle application must be made, with the use of a backboard where possible. These foams are not suitable for subsurface injection.

Regular foams tend to be slower than other foams in their ability to control and extinguish fire. They are not suitable for polar solvents, alcohols, etc., and they may not exhibit compatibility with all dry chemical extinguishing agents.

(B) A.F.F.F.

Aqueous film-forming foams are a combination of fluorocarbon surfactants and synthetic foaming agents. AFFF is fast spreading, providing a film across the surface of hydrocarbon fuel, excluding vapor and providing a cooling action to the material. The fast-spreading action is necessary in crash/rescue firefighting where time factors and a fast knockdown are critical to rescue operations. The characteristics of AFFF also have been found effective in open spill fires where foam can be delivered through aspirating and non-aspirating nozzles, such as fog nozzles.

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(Caution should be observed in the use of non-aspirating nozzles because of the type of foam produced. Knockdown will be observed in small spill fires but the blanket produced might be unstable. The healing effect would be compromised as compared to aerated AFFF.) Another plus of AFFF is that it is compatible with dry chemical extinguishing agents.

The tradeoffs that AFFF must make to attain the fast knockdown feature must be considered. First, its short initial drainage time causes the substance to break down more quickly, affecting heat resistance and blanket life and limiting the amount of time available to make rescues. The short drainage time also lowers burnback resistance, the ability of the foam blanket to remain in place when agitated or disturbed. This can expose operating forces to a reflash and make overhauling dangerous unless AFFF is continuously applied. Also, AFFF's inability to adhere to hot vertical or horizontal metal surfaces leaves an exposed area in the blanket which can cause reignition.

(C) AFFF/ATC

AFFF/ATC is Light Water brand Alcohol Type Concentrate. It displays the same characteristics as AFFF except it can be used on Class B hydrocarbon fires, water-soluble polar solvents and water-insoluble hydrocarbon flammable liquids. According to the manufacturer it provides better burnback protection on water-soluble polar solvents than non-AFFF agents. It can be used with both aspirating and non-aspirating equipment. Manufacturers' literature states that AFFF/ATC has subsurface injection capability, and that Light Water ATC is effective in subsurface systems for gasoline, crude oil and most fuel blends. This product is recommended for general fire service use.

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(D) High Expansion Foam

This Foam Liquid is designed for use through air aspirating devices producing foam expansions from 100 up to 1000 to one. These very high expansion ratios produce large quantities of finished foam from relatively small amounts of water and foam liquid.

High Expansion Foam is primarily intended for use on Class A type fires in confined areas such as basements, mine shafts, attics, and other places inaccessible to the firefighter. By placing a High Expansion foam generator at an opening into confined space and providing proper ventilation at a point opposite the generator, a fire can be brought under control without personnel having to enter a potentially hazardous space. High Expansion Foam controls fires by (1) cooling; (2) smothering; (3) reducing oxygen content by steam dilution. Care must be exercised in positioning the foam generator so that products of combustion are not drawn into the air inlet. Ventilation must be carefully planned to allow foam to reach all areas of the confined space.

High Expansion Foam has demonstrated some utility on flammable liquid spill fires. If sufficient quantities of High Expansion Foam can be safely and effectively delivered to the fire, and if wind conditions and thermal updrafts are not too severe; spill fires of limited size can be effectively extinguished.

4. HYDROCARBON FUELS

In chemistry, a hydrocarbon is a compound of hydrogen and carbon:

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Methane CH_4

Ethyne C_2H_2

Ethene C_2H_4

Benzene C_6H_6

(a) Hydrocarbon fuels such as diesel fuel oil, jet fuels, gasoline, toluol, etc., can be controlled or extinguished with the aqueous film forming foam (AFFF) as well as protein foam.

(b) Hydrocarbon fuels are listed Not Water Soluble.

POLAR SOLVENTS

Polar, meaning a linking of atoms by a bond which electrons are not shared equally resulting in slight charges on the atoms. Compounds with polar bonds tend to be soluble in water. A polar solvent is a liquid whose molecules possess a permanent electric movement. Examples are amines, ethers, alcohols, esters, aldehydes and ketones. In firefighting, any flammable liquid which destroys regular foam is generally referred to as a polar solvent.

Polar solvents can be controlled or extinguished with Aqueous Film Forming Foam (AFFF) with alcohol type concentrate ATC.

POLAR SOLVENTS ARE LISTED AS WATER SOLUBLE

5. APPLICATION OF FOAM

In general, foam should be applied to the fire as gently as possible. The foam stream should never be applied directly

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onto the flammable liquid surface unless there is no other approach. The maximum reach of the stream should be used, letting the foam do the work. A foam blanket should be about three inches thick.

If the incident is a spill fire on level ground the stream should first be directed to the side, away from the fire, until foam comes from the nozzle. Then the foam stream is directed onto the ground in front of the fire. With a slow sweeping motion the foam blanket is slowly worked onto the fire. The foam stream should never be directed into an existing foam blanket. The force of the stream could blow the existing foam from the surface.

If the fire is in a tank or located so the method above cannot be used, the stream should be directed against the side of the tank or some other object. The tank wall or other object is then a splash board, permitting the foam to slide gently onto and across the liquid surface.

If for any reason foam stops coming from the nozzle the stream should immediately be removed from the foam blanket to prevent washing it away. Operating pressures are very important for the production of quality foam. The acceptable nozzle and proportioner pressures recommended by the foam and device manufacturers should be observed. Overpressures result in a deterioration of quality; underpressures shorten throw and will not produce well expanded foam.

There are several cautions that must be remembered when foam is being used. Regular water streams can be used to cool adjacent materials or to protect exposures, but should never be used in such a way as to disturb the foam blanket. Foam streams are more electrically conductive than is regular water - even as a fog stream there is great potential danger, so foam should never be used on energized electrical equipment. Entraining contaminated air (dust, products of combustion) should be avoided - it has negligible effect on low expansion foam, but can reduce the quality of high expansion foam. Remember that foam really is just bubbly water - don't use it on materials that react with water.

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6. FORMULA TO DETERMINE FOAM QUANTITY

There are two basic types, 6% and 3% which, when proportioned with water, produce 6% and 3% solutions by volume. This means that when using a 3% concentrate, 97% water is added to make the foam. In the same manner, when using a 6% concentrate, the water portion is 94%. Air is then added to the mixture to expand the solution into the finished foam product. The expansion ratio varies between the manufacturers from 1:7 and 1:12. Foam with this type of air ratio is known as low-expansion foam. A 22.7 litre can of 3% concentrate foam will require 735.1 litres of water. This number can be determined as follows:

$$\frac{\text{QUANTITY OF FOAM}}{\text{PERCENTAGE OF CONCENTRATE}} = \text{TOTAL SOLUTION}$$

$$\text{TOTAL SOLUTION} - \text{QUANTITY OF FOAM} = \text{QUANTITY OF WATER}$$

In the preceding example the quantity of foam is 22.7 litres and the percentage of the concentrate is 3%.

$$\frac{22.7}{0.03} = 756.7 \text{ litres total}$$

$$756.7 - 22.7 \text{ litres of concentrate} = 734 \text{ litres of water}$$

Having a total solution of 734 litres and using a 1:10 expansion (average) ratio, the finished foam product would be $734 \times 10 = 7340$ litres of finished foam.

The 3% foam has several advantages over the 6% variety. These are:

1. Longer application times
2. Smaller storage space

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7. FOAM PRODUCING EQUIPMENT

Double Tuff Nozzle and Eductor

(a) In-line eductor 65mm - 65mm

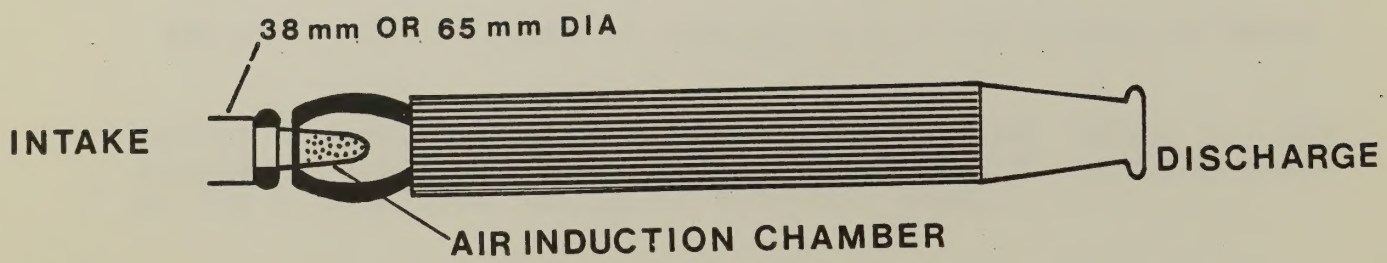
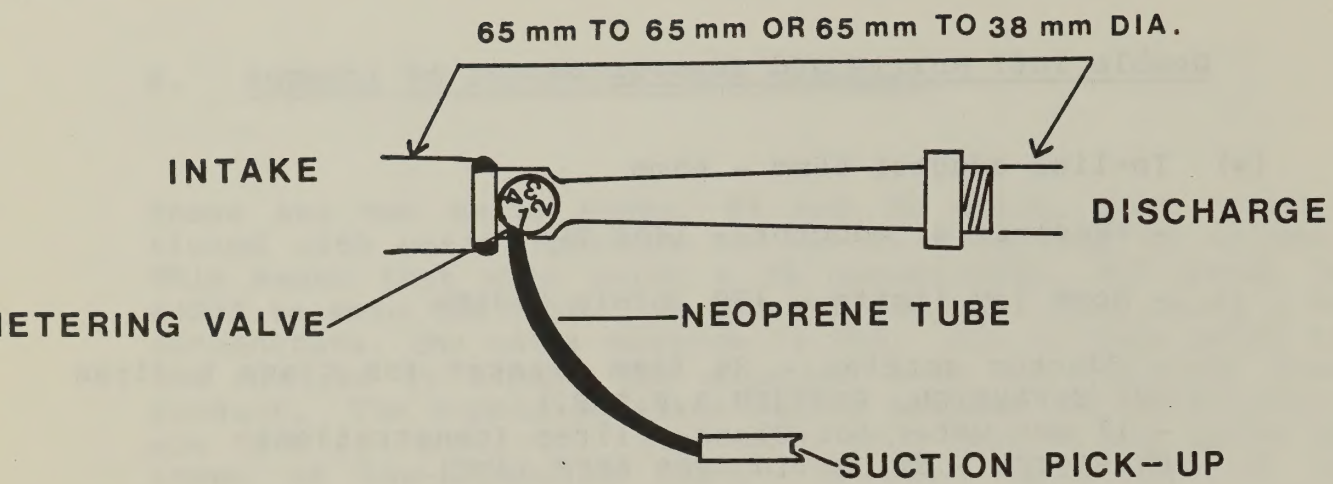
- Pressure at eductor - 1400 KPa
- Hose lay limits - 450 L/min @ 360m
- Eductor setting - 3% foam blanket for Class B fires (Hi EXPANSION, PROTEIN A.F.F.F.)
- 1% wet water for Class A fires (penetration)
- EXCEPTION - 6% SETTING FOR AFFF (ATC)

(b) In-line eductor 65mm - 38mm

- pressure at eductor - 1400 KPa
- Hose lay limits - 360 L/Min. @ 45m.
- Eductor setting - 3% foam blanket for Class B fires
- 1 % wet water for Class A fires (penetration)
- EXCEPTION - 6% Setting for AFFF(ATC)

NOTE: After use flush all equipment thoroughly.

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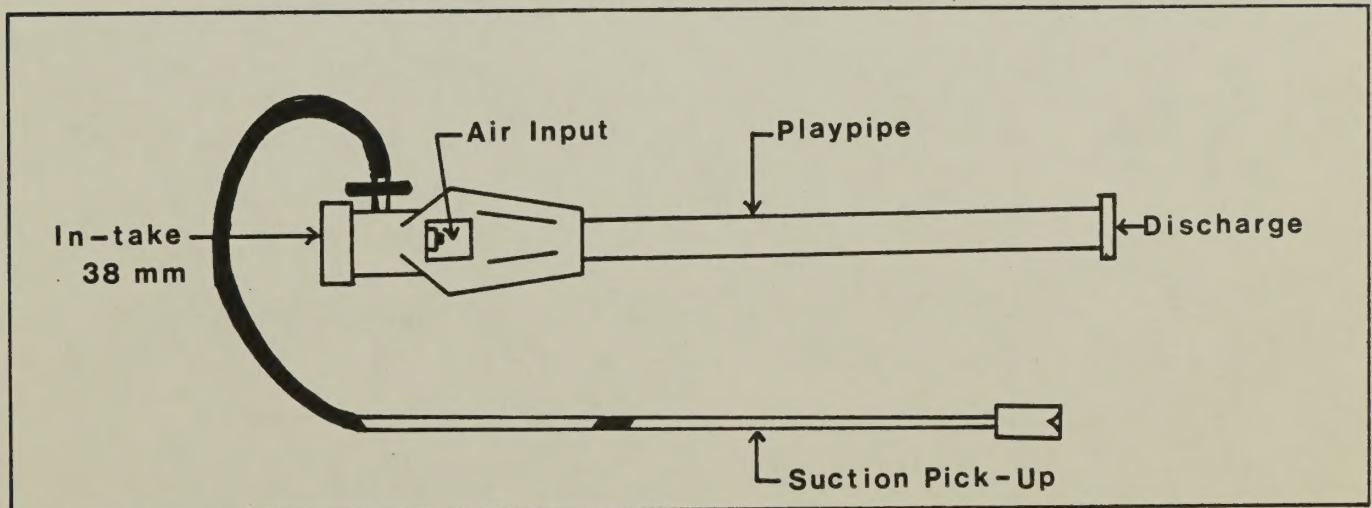


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Foam Hip Pack

- 700 KPa at Eductor.
- used in conjunction with 38mm hose.

NOTE: Flush all equipment thoroughly after use.



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ELKHART HYDRO - FOAM NOZZLE H F 500

The Hydro-Foam nozzle is one of the most efficient and effective tools for AFFF firefighting available today.

The nozzle's unique design, with built-in eductor, allows it to be attached to any existing fixed monitor, portable monitor, or deck gun. The nozzle can also be used with plain water for cooling exposures or for fire attack. When the need arises for high application rates of AFFF, simply inserting the pick-up hose into your foam supply produces an instant AFFF foam system. In many cases, knock-down of large fires can be achieved while hand lines are being pulled for final extinguishment.

The HF nozzles are constructed of rugged brass alloys. The nozzle tip turns on a cam mechanism to easily change stream patterns. This cam should be lubricated periodically with a light petroleum base grease to insure smooth operation.

The quick connect coupling is a convenience option. It allows you to keep the suction hose stored until the need for foam arises. You can then quickly attach the hose and start foam operations.

<u>Model</u>	<u>Flow Rate*</u>	<u>Threads</u>	<u>Proportioning Rate</u>
HF 500	1900 Litres	65mm	6%

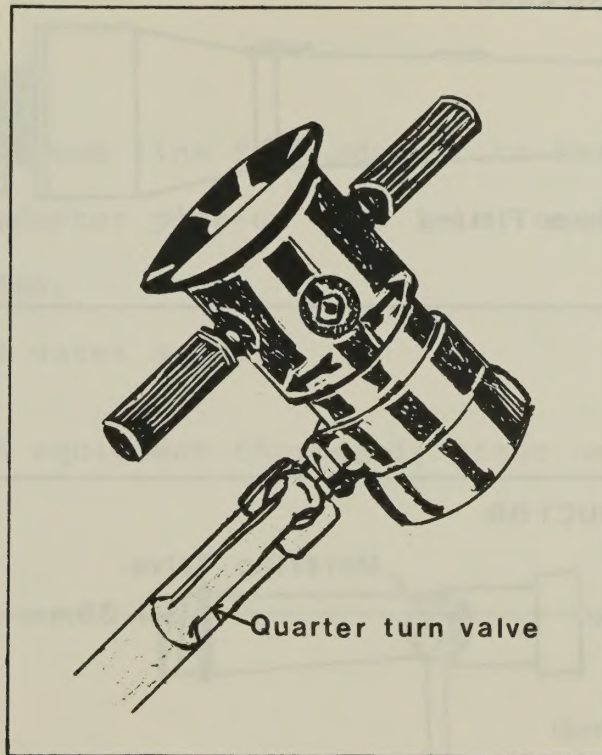
Effective Reach @ 700 kPa

<u>Weight</u>	<u>Straight Stream</u>	<u>Narrow Fog</u>	<u>Wide Fog</u>
6 Kg	45 metres	21 metres	8 metres

*Nozzle is rated @ 700 kPa but will pick up foam with as little as 350 kPa.

As with any other foam appliances be sure to flush foam lines with clean water after each use.

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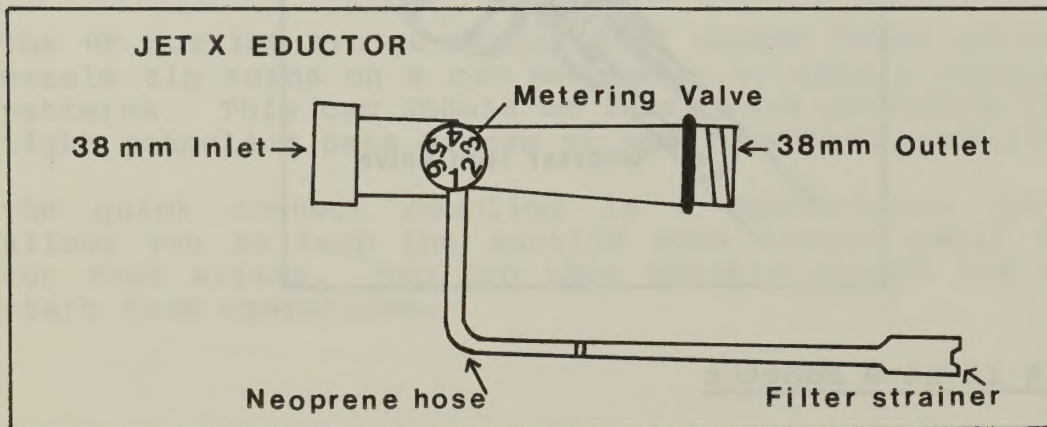
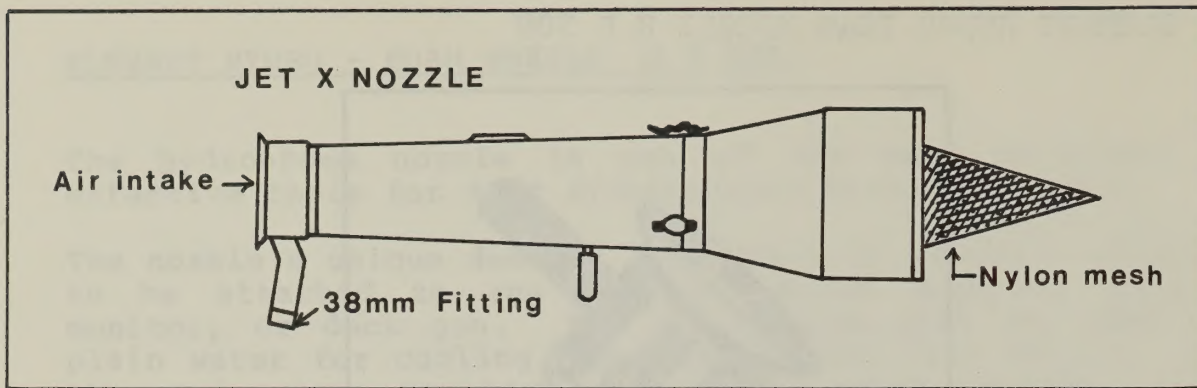


Jet X In-Line Eductor

- used to introduce foam solution into hose stream.
- Maximum of 150 metres of 38mm hose between eductor and Jet. X Nozzle.
- Pressure Maximum - 1750 KPa
- Eductor can be placed on 38mm discharge part or on 65mm hose reduced to 38mm.
- Friction loss in 65mm - 20 KPa per 30 metres
38mm - 82 KPa per 30 metres
- 3% setting on metering valve.
- use with high expansion foam.

NOTE: Flush all equipment thoroughly after use.

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M.S.A. Foam-Maker Model 3000

- Foams capacity 14000 litres/min (good for total flooding application)
- Water supply 140 litres/min at 420 KPa at foam-maker.
- Eductor setting 2% (preset)
- Use with high expansion foam concentrate only.
- If using extension duct on foam-maker do not exceed 1.5 metres in elevation above eductor.

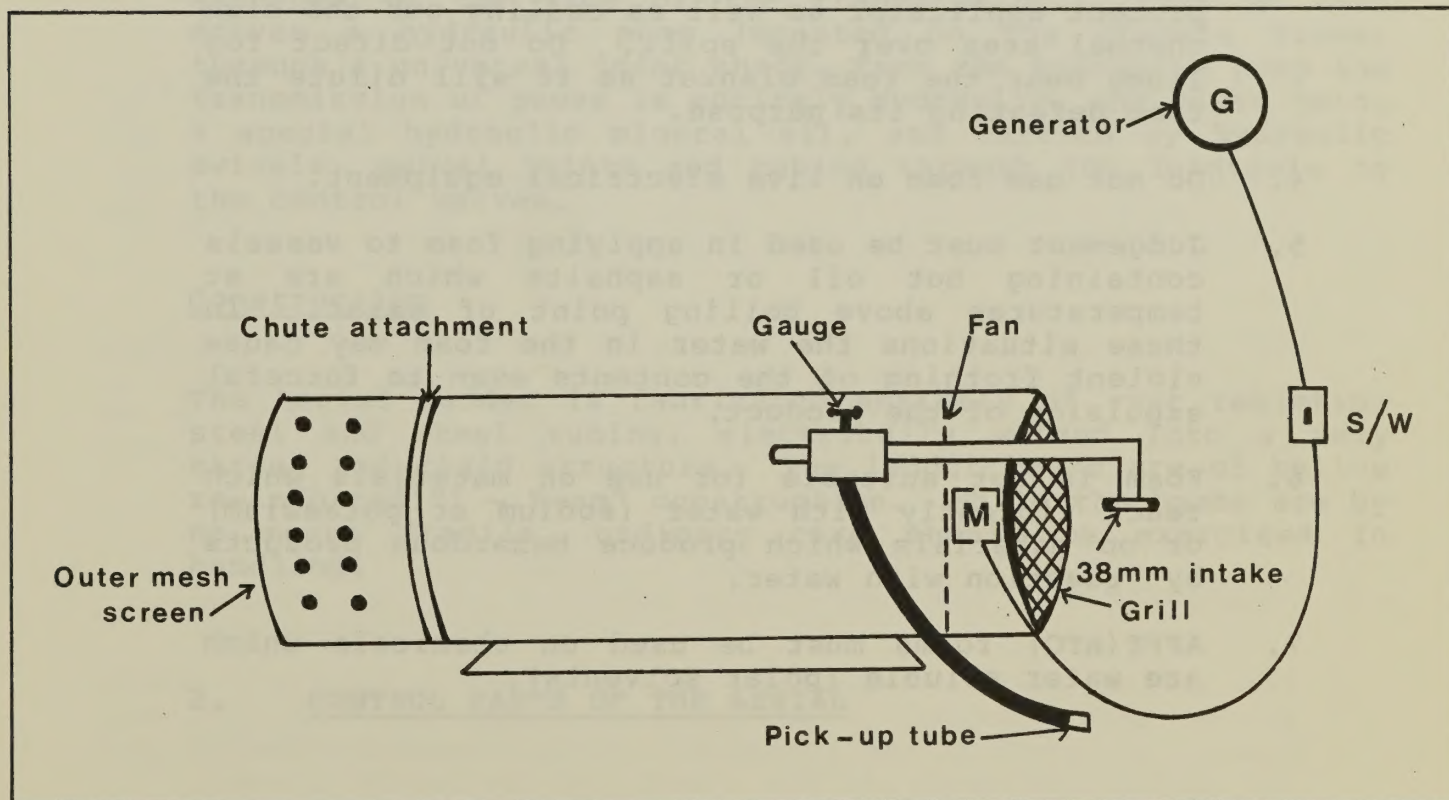
Operating Procedure

- (a) Connect power supply.
- (b) Connect water supply to eductor inlet.

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- (c) Connect hose line from eductor to foam-maker.
- (d) Place eductor pick-up tube into foam-maker.
- (e) Start fan.
- (f) Turn on water supply.

NOTE: Flush equipment thoroughly after use.



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8. GENERAL INFORMATION

1. Three essentials for making mechanical foam: air-water-concentrate.
2. Volume and quantity of foam will vary with operating temperatures. Better foam is produced when weather is warm and water is not as cold.
3. When using foam on Class 'B' fires you should always use a back up line with full fog pattern to protect applicator as well as cooling out the high thermal area over the spill. Do not direct fog lines near the foam blanket as it will dilute the foam defeating its purpose.
4. Do not use foam on live electrical equipment.
5. Judgement must be used in applying foam to vessels containing hot oil or asphalts which are at temperatures above boiling point of water. In these situations the water in the foam may cause violent frothing of the contents even to forceful expulsion of the product.
6. Foam is not suitable for use on materials which react violently with water (sodium or potassium) or on materials which produce hazardous products by reaction with water.
7. AFFF(ATC) foams must be used on chemicals which are water soluble (polar solvents).

NOTE: FOR ADDITIONAL INFORMATION REFER TO
I.F.S.T.A. MANUAL.

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CHAPTER 14

OPERATION OF THE AERIAL LADDER

1. INTRODUCTION

Principle Of Operation

The power for operating the Aerial Ladder hoist and also the ladder extension and rotation is derived from the truck engine, driving a conventional "Power-Take-Off" (P.T.O.), attached to the side of the transmission. This in turn drives a hydraulic pump (mounted on the chassis frame) through a universal joint shaft. From the hydraulic pump the transmission of power is entirely hydraulic, the fluid being a special hydraulic mineral oil, and carried by hydraulic swivels, swivel joints and tubing through the turntable to the control valves.

Construction

The Aerial Ladder is fabricated entirely of rust resisting steel and steel tubing, electrically welded into a very strong and rigid structure. The ladder beams are of hollow re-inforced "I - Beam" construction. While the beams are by no means fragile, ordinary care should be exercised in handling.

2. CONTROL PARTS OF THE AERIAL

Hoisting Cylinders and Extension Cables

Hoisting cylinders are sometimes referred to as elevating cylinders. They consist of heavy, seamless-steel outer

shells bored to an extremely smooth finish on the inside. The hoisting cylinders are often chrome plated on the inside to resist friction and wear. The cylinders are enclosed at the top and bottom by removable caps. A solid piston rod, packed and tightly fitted with rings, is inside each cylinder. The piston rods are also chrome plated to resist wear. One end of each piston rod is equipped with a trunnion anchored to the turntable or to the ladder. The trunnions hold the piston rods in contact with the ladder or turntable. This allows the pistons to transmit the force of the hydraulic fluid in the cylinders to the ladder and raise the bed section. The amount of force created by the hydraulic fluid depends on the actual hydraulic pressure and the size of the piston surface area. The larger the piston area, the more upward force will be produced. Normal hydraulic pressure is from 5700 to 6800 k.P.a.

Many new hoisting cylinders are equipped with integral safety valves that lock or hold oil in the cylinder in the event of a leak or tubing blowout. In this situation the ladder can only be lowered by a manual bleed-down valve. This safety feature will avoid damage to the ladder or injury to the firefighters on the ladder.

The hoisting and retracting cables are usually galvanized aircraft type made from plow steel and are resistant to abrasion. The cables are designed and constructed to be much stronger than is necessary. This is a built-in safety factor.

The Turntable

The aerial ladder turntable is constructed of rigid steel plates and provides a surface on which the operator may stand. Located on the turntable is the control pedestal and all mechanisms required for operating the aerial ladder.

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The primary function of the turntable is to provide right and left rotation of the aerial ladder on a horizontal plane of 360 degrees. Turntables generally operate upon three rings that are mounted on ball bearings underneath the turntable. Gear teeth are provided on the outer periphery of the turntable, and these teeth engage gears that rotate the turntable. Although aerial ladder turntables may differ in mechanical features, their operating principles are similar. Most aerial manufacturers provide a manually operated device in addition to mechanical controls in case one system fails.

Control Pedestals

The operator's control pedestal usually stands waist high and is positioned to the side of the aerial ladder, on the turntable. The top of the pedestal is generally designed with a sloping panel for ease in reading the instruments that are mounted on it. There are usually three main levers to control hoisting, extension, and rotation. Operation of the hoisting lever either raises the entire ladder vertically to any angle with the ground or lowers the entire ladder toward the horizontal position. Operation of the extension lever either extends or retracts the sections of the ladder. Operation of the rotation lever regulates the right or left circular movement of the turntable. Each control lever also regulates the speed of each operation. Other controls and instruments located on or near the control pedestal are the engine-starter switch, light switch, hydraulic-oil pressure gauge, cylinder pressure gauge, bypass valves, extension indicator, stop and lock controls, inclinometer, and hydraulic lock valve. Also present is the intercom system and the remote control for the mounted nozzle.

Hydraulic-oil Pressure Gauge

All aerials are equipped with a pressure gauge. This records the low or "initial pressure" (approximately 1000 kPa) and also the "High Pressure", or the working pressure. (Approximately 7000 to 10000 kPa.)

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Cylinder Pressure Gauge

This gauge records the pressure in the hoisting pistons. This gauge is white and has a red section on it. When the needle is in the red section of the gauge, it indicates there is a high or excessive pressure in the hoisting pistons. This would only occur when the ladder is:

1. Over extended at a very low angle.
2. Excess weight on the ladder.

If this occurs, the operator must take measures to correct it such as:

1. Retract flys.
2. Obtain a better angle of the ladder.
3. Remove some of the weight from the ladder.

Aerial Ladder Locks And Stops

Locks and stops are provided for safety. Ladder hold-down locks, mounted on the aerial ladder supports, prevent the aerial ladder from bouncing up and down when the apparatus is in motion. Most hold-down locks are operated either hydraulically or by a vacuum powered cylinder. In either case, they usually operate automatically just before the ladder is to be hoisted.

Automatic stops are provided that will prevent overtravel while the aerial is being elevated, lowered, extended, or retracted.

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A lever-actuated ladder lock is connected by cables to the dogs, or pawls, and secures the sections in position. This lever is usually located at the base of the ladder near the control pedestal.

The purpose of the ladder locks is:

1. To align the rungs for easier climbing.
2. To strengthen the ladder.
3. To take the weight of the ladder off the cables.

The ladder should be extending when the ladder locks are applied or taken off. Ladder locks should be applied for all evolutions. Care should be taken during rescue operations that the added weight applied to the end of the ladder does not affect the releasing of the ladder locks. The ladder locks should be applied just before the proper height is attained so that there is a minimum of wear caused from the locks passing over the rungs.

Stabilizers

All aerial ladder apparatus are equipped with hydraulic stabilizers to provide rigid support of the vehicle when the aerial ladder is in use. These stabilizers are often referred to as outriggers or jacks. Operating pressure is 4100 to 5500 kPa.

Stabilizers extend horizontally or diagonally from the apparatus frame to prevent the vehicle from tipping over when the aerial ladder is in use. An interlock system is provided on some apparatus to prevent operation without the stabilizers properly in place.

The following are some suggestions for stabilizing aerals:

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1. Wheels should be braked and chocked before lowering jacks.
2. Caution should be taken when lowering and raising jacks to see that they don't hit people or objects.
3. If on a hill have the apparatus facing UP THE HILL rather than down.
4. If operating on soft ground, use large planking under the jacks where possible, operate off the rear or the front of the truck or keep as close to these positions as possible.
5. If the ladder is being heavily loaded while at a very low angle, a ground ladder may be used as an intermediate brace. (Rescue of people.)
6. Where aerials are used in high winds, it is well to consider applying guide ropes if the ladder is well extended.
7. There should never be more than one man on the top section of the ladder during a water tower operation.
8. Avoid shock loads to the aerial and the vehicle when extended.
9. Operate aerial off of front or rear if possible, this is always good practice.

Operating The Controls

It will be observed that each operation such as rotating, hoisting, and extending are described as being separate operations. This procedure should be adhered to, at least until the operator has become thoroughly familiar and proficient in handling the controls.

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This should ALWAYS be done if there are any poles, wires or other obstacles that might interfere with free manipulation of the ladder. After the operator has become an expert in the handling of controls, it is quite possible to rotate the ladder while it is being hoisted to the proper angle. Also the angle of the ladder may be adjusted slightly while being extended as it is seen that a change in the hoisting angle is necessary. It should be remembered that very little time is saved in doing two evolutions at once as this cuts both evolution speeds in half. In any event, the ladder should be hoisted to an angle of 45 degrees before starting any extension.

3. POSITIONING

In an actual fire or other emergency that demands aerial ladder operations, the stopping or positioning of the truck can be of vital importance. It has to be very accurate because changing the trucks' location after operations are underway can be a time consuming and perhaps a dangerous move. It should be close enough to be able to do the required job with out putting any undue strain on the aerial. Consideration as to the safety of the truck and personnel must be given as well, and thought must be given to positioning of the aerial for rescue and easy access to ground ladders, and also to extinguish the fire. It must also cover the fire if it extends its boundaries. A good method to use in spotting the aerial correctly, is to spot the turntable directly in line with the position in which the tip of the aerial will rest or where the stream will be injected.

4. PREPARING AERIAL LADDERS FOR USE

After an aerial ladder apparatus has been spotted, the operation of certain controls is necessary to prepare the apparatus for use. These operations will be considered

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according to the sequence in which they should be performed. There are three general steps that must be taken to prepare an aerial ladder for use.

a) INSIDE CAB

Set Braking Devices and Engage Hydraulic Pump

These systems are dependent upon the apparatus engine for power. The air brake requires compressed air, and hydro-vac requires a vacuum from the intake manifold of the apparatus engine. When the engine is not running, or if the engine dies, these brake systems may gradually bleed off and fail to hold. One braking system alone should not be relied upon during aerial ladder operation.

Hydraulic oil pumps on aerial ladders are positive-displacement pumps that circulate the hydraulic oil under pressure to operate the aerial ladder. The hydraulic oil is contained within a supply tank and is pumped through tubing to the control mechanism and back again to the supply tank. A relief valve is provided within the hydraulic circuit to prevent serious damage if an operator attempts to retract the ladder with the locks engaged or if the control levers are in the neutral position. To engage this pump, the operator need only disengage the apparatus drive clutch and engage the power takeoff system. Since the pump is driven by a power takeoff gear, it will be in operation when the clutch is released. Some aerial apparatus are equipped with an emergency backup system that consists of an electrically driven hydraulic pump to provide emergency hydraulic power.

Aerials With Standard Transmissions

1. Position apparatus and apply brakes.
2. Depress clutch

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3. Wait 5 seconds and then engage the P.T.O.
4. Release clutch.

NOTE: Transmission must be in NEUTRAL when operating P.T.O.

Automatic Transmissions

1. Position apparatus and apply brakes.
2. Place transmission in "DRIVE" to stop gears from turning.
3. Engage the P.T.O. (NOTE: On some aerial trucks the spring lock-out must be engaged with a switch in the cab)
4. Place transmission in "NEUTRAL" and apply LOCK.

Stabilize the Apparatus

It is necessary for the chassis of aerial ladder apparatus to be somewhat longer than other types of apparatus. When an aerial is raised and extended to either side of the chassis, the wheel span is not adequate to take all the back thrust and leverage of the long, heavy ladder. It is, therefore, desirable to broaden or widen the base of the supporting chassis beyond the span of the wheels. Stabilizers are provided for this purpose. Remember to always place wheel blocks in position during the stabilizing of the aerial truck.

Placing Aerial Ladders In Position

To place an aerial ladder in position means to elevate, rotate, and extend the ladder assembly and to lower the ladder to the place where it must be used. Although it is possible to perform these operations simultaneously, they should be performed separately.

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Slow, steady operation of a ladder control will insure smooth movement of the aerial ladder assembly. The farther the operator moves a control, the faster the ladder will move (up to the maximum speed). Maximum speed, without the ladder jerking, can be obtained by slowly moving the control to the higher speed position.

Elevate the Ladder Assembly

Only that portion of the aerial ladder that constitutes the ladder assembly is considered here. This assembly includes the bed ladder, its extension fly sections, hoisting cylinders, cables, safety locks, and the controls that operate the assembly. To elevate the ladder assembly means to raise the entire assembly from its stored position toward a vertical position.

To raise the nested ladder from its stored position requires an operator to move the cylinder control lever slowly toward the raise position. This movement actuates the elevating cylinders, which raise the nested ladder from the arches. The cylinder control lever must be returned slowly to the neutral position when the ladder has reached the desired height. The turntable brake or lock, if there is one, should be released before rotating the ladder. The operator at the control pedestal regulates the speed of operation.

Good judgment on the part of the operator, concerning how high to elevate the ladder assembly, is most essential. It is considered good practice to always elevate the ladder assembly slightly higher than the point where it will be used. This practice allows the ladder to be lowered into position after the fly sections have been extended. An operator's judgment of elevation can be developed and improved only by practice and actual experience.

Rotate The Ladder Assembly

After the ladder assembly has been raised to the desired height the entire assembly should then be turned or rotated

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until the tip of the assembly is pointing toward the objective. A slow and steady operation of the control will insure the same movement during rotation and stopping. Sudden stops tend to whip the ladder assembly.

Extend Fly Sections

With ladder assembly adequately elevated and rotated into position, the fly sections may be extended. Fly sections of an aerial ladder are connected by a halyard cable. This cable operates through a series of pulleys and is wound around a cable drum at the turntable. This step requires an operator to move the extension control lever slowly toward the extended position, which actuates the extension cable drum and moves the ladder section. Return the section control lever slowly to the neutral position when the top of the ladder is well above the object to be reached.

An operator can develop good judgment concerning how far to extend the fly sections through regular practice and experience. Any extension locks that may be provided on the apparatus should be released before extension operations, and should be set in place or locked immediately after extension and before the ladder is used.

Lower To Objective

Modern aerial ladder construction permits an aerial ladder to be used with its tip either supported or unsupported. Department policy, manufacturer's recommendations, and the use to which the ladder is put should regulate how far the ladder should be lowered. The control that actuates the lowering of the ladder to an objective is the same control that is used to elevate the ladder assembly, except it is usually moved in the other direction. The important factors to be considered when lowering to an objective are to lower slowly, evenly, and steadily. It may be necessary to stop the movement of the ladder occasionally and to further extend or retract the fly sections, but sudden stops should be avoided.

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This step requires an operator to move the cylinder control lever slowly toward the "lower" position. This action releases the pressure on hydraulic oil in the cylinder and permits the ladder to lower slowly. Return the cylinder control lever slowly to the neutral position when the ladder is within a few inches of the object that is to be reached. When the ladder is in position for use, all ladder locks, hydraulic valve locks, turntable locks, and other safety features must be set or activated.

5. CLIMBING ANGLE VERSUS LADDER LOAD AND EXTENSION

The best angle for the ladder to be set for climbing is from 70 to 80 degrees from horizontal. When at these angles it is perfectly safe to have six to eight men of average weight (or 550 Kg. load) distributed on the ladder at one time, provided the upper end is supported against the building. (These ladders have been tested with 11,000 kg. loads, distributed throughout the entire length, without signs of distress.) If the upper end is not supported, not more than three or four men should be on the ladder at one time, and not more than one or two if their weight is concentrated at the top. With men on the unsupported ladder, it is of utmost importance that the ground jacks be extended in position. For safe climbing angles, refer to pedestal indicator.

The following is the permissible load allowed in correspondence to the angle of the ladder for climbing purposes only when the ladder is supported.

<u>Angle</u>	<u>Permissible Load</u>
70°	8 men - with an approximate weight of 81 kg. each.
60°	6 men - with an approximate weight of 81 kg. each.
45°	4 men - with an approximate weight of 81 kg. each.

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In all cases the load is assumed to be distributed approximately equally over the entire length of the ladder when it is fully extended. It should be remembered, that concentrating the load in the middle of the ladder span when supported at the top, approximately doubles the stress on the ladder structure over that imposed if the load is equally distributed.

6. DEFINITION OF A SUPPORTED AERIAL LADDER

In the top and supported position, the touch point of the ladder, unloaded, should be 20 cm from the touching surface of the building. This will put the trussing in tension as load is applied and provide the maximum load carrying capacity.

As load is applied (men climbing the ladder) it will move in toward the building until it is touching or resting on the same. This puts the stress on the end of the ladder instead of on the centre where the ladder is weakest.

7. OPERATING AERIALS AROUND ELECTRIC WIRES

When the emergency necessitates the operation of aerial ladders in the close vicinity of electrical wiring, the power company should be notified to cut the circuits of the wiring involved.

Exercise care in all cases around such hazards. Consider all wires as charged, even though they are not normally so; fallen electrical wires in the vicinity may have charged them.

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The essential point is never to provide a ground for an electrical circuit. If the ladder actually makes electrical contact, the safest course for the operator to follow is to get away from the controls and touch nothing until the power is off. Personnel on the ladder should keep their hands and feet on rubber covered rungs until the circuit is cut. ONLY if it becomes necessary to leave a charged vehicle should personnel jump off. When you jump, JUMP SO THAT CONTACT WITH THE VEHICLE AND GROUND IS NOT MADE SIMULTANEOUSLY.

Personnel should be made aware of the fact that when jumping from an electrically charged vehicle, that there is a possibility of electricity arcing from the vehicle to ground, through the person's body. This electrical arc passing through a person's body could, and in most instances will be fatal.

CAUTION: Members on the ground must keep clear of the charged vehicle. Personnel returning to apparatus for needed equipment should ascertain whether it is electrically charged or not before touching the vehicle.

NOTE: The operator of any vehicle involved in this kind of situation must stay near enough to the vehicle, if he has jumped off, to warn other personnel of the danger.

8. REMOTE CONTROL NOZZLE

The remote control nozzle is designed for use at the tip of aerial ladders with a control panel mounted on the pedestal on the turntable. This nozzle does not require a man to operate it from the tip of the ladder. The remote controls permit the nozzle to be moved up or down as well as changing the fog pattern. It is not possible to rotate the nozzle sideways, this must be done by rotating the turntable.

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The remote control nozzle is equipped with two separate electrical motors. One, is used for control of the elevation of the nozzle, and one, is used to control and select the fog pattern. Both of these are operated separately from the base of the ladder on the pedestal. Electric current is fed to the nozzle through a heavy cable carried on a spring loaded wheel mounted on the turntable.

9. AERIAL WATER TOWER HOOK-UP

a) Pre-Connected Remote Control Nozzle

- 1) #3 Man, the driver will position and prepare aerial for operation under the guidance of the Officer in charge.
- 2) #2 man hands the triplex and hose to #1 man who will place same on the ground at the turntable. (Opposite the fire side.)
- 3) #2 man will assist to guide the hose up the ladder as it is extended to prevent binding of the hose. (Hose straps are pre-connected 5 rungs from top and 2 from the bottom.)
4. #1 man will assist in hooking up supply lines to triplex.

b) Manual Nozzle (Mounted)

- 1) Follow steps 1 - 3 above.

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- 2) #1 man will don safety belt and S.C.B.A. He will then take up a position at the top of the aerial, making sure he has the handle with him for the manual water tower nozzle.

(ONLY ONE PERSON ON TOP SECTION OF THE LADDER DURING LADDER PIPE OPERATIONS)

NOTE: If time and conditions permit, while #1 is donning the belt, etc., #2 man may assist in connecting hose from the pumper to the triplex.

10. GENERAL SAFETY FACTORS

- * All ladders are stronger when the load is applied perpendicular to the rungs than when the load is applied laterally.
- * The lower the hoisted angle of the ladder (angle from horizontal) the less load it will safely carry.
- * When unsupported at the tip, and with a hoisted angle less than 50 degrees, the ladder will carry approximately one-fourth of the load it would carry if placed against a building in accordance with manufacturer's instructions.
- * When unsupported, a concentrated load at the tip imposes approximately twice the stress on the ladder than the same load would impose if distributed over the length. The safe load that a ladder will carry is reduced as the ladder is extended. A ladder will safely carry approximately twice the load at 12 metres of extension that it will at 24 metres. (Actually, the difference is much greater because of the strengthening of the overlapping sections.)

(1986)

- * A shock load, such as a person jumping onto a ladder, may impose stresses several times those involved if the load were normally applied.
- * When a ladder must be extended and used beyond the recommended limits, the ladder should be extended parallel to the apparatus (over the front or the rear end of the apparatus). This gives maximum stability against tipping under such adverse conditions.
- * If unable to extend the ladder over the exact front or rear, try to keep it as close to these positions as possible.
- * When placing the ladder, always ease it gently toward the objective. When moving the ladder in any manner, it must be clear of the objective, to prevent scraping.
- * If the ladder must be used beyond the recommended limits at low angles, ground ladders may be used as intermediate braces.
- * Engage ladder locks before climbing ladder.

NOTE: FOR ADDITIONAL INFORMATION REFER TO I.F.S.T.A. MANUAL

(1986)

CHAPTER 15

WATER SUPPLIES FOR FIRE PROTECTION

1. INTRODUCTION

A good water supply is of primary concern to any progressive Fire Department. The importance of a good relationship between the Fire Department and the Water Utility cannot be overstressed; however, Fire Departments must bear in mind that the Water Utility has matters other than fire protection claiming their attention.

2. THE TYPES OF WATER SUPPLY SYSTEMS INCLUDE THE FOLLOWING.

Gravity is used in a community that has a natural water source higher than the community itself. The natural pressure created by the difference in elevation is a great aid when utilized to distribute the water. Since ten kPa of pressure results for every metre of elevation, a reservoir seventy-five metres above the community would provide a static pressure of 750 kPa. This principle is also utilized in manufacturing plants to feed a sprinkler system by way of a storage tank which is elevated.

Direct Pumping System - To move water through pipes where adequate elevation is not available to take advantage of gravity, pumps are required. Direct pumping systems move water directly from the source into the distribution system with very little or no elevated storage. Water systems with elevated storage are most common, but direct pumping systems may be highly efficient. Direct pumping systems may be computer controlled and use variable speed pumps, pressure regulating devices, auxiliary power supplies, all of which are completely automated.

Combination System - This system is a combination of direct pumping and gravity, and is the type used in most communities. Pumps are arranged to take water from the source and discharge it directly into the distribution system or through filters and then into the system. Standpipes and elevated storage tanks or reservoirs are located at strategic points in the system and are reserve storage containers. These reserves may be located at the end of a long feeder line, at extreme boundaries of the system, or near the centre of an area which has exceptional peak demands.

With such systems, water may be pumped into the distribution system at a uniform rate. When demand is less than the rate at which the water is being pumped, the excess will automatically go into a reservoir. When the demand is greater than that being supplied from the pumping station, water will flow back from the reservoir or storage and into the system.

3. THE DISTRIBUTION SYSTEM

This is that part that receives water from the pumping station, and delivers it throughout the area being served. Fire hydrants, gate valves, reservoirs and standpipes are all supplementary parts of the system.

When hydrants are supplied from more than one direction, there is much less pressure lost due to friction. A grid or looped system is just such a system, and can be said to have a circulating feed. A grid or looped system consists of the following:

1. Primary Feeders which are large pipes or mains relatively wide spread and convey large amounts of water to points in the system where smaller mains are fed, and distribute the water. Primary feeders are 400 mm and larger.

(1986)

2. Secondary Feeders form a network of intermediate sized piping which reinforce the grid within various loops of the primary feeder system and aid in the providing of fire flow at any point. Secondary feeders are 300 mm.
3. Distributors are a grid arrangement of smaller mains which serve individual hydrants and blocks of consumers. The size of these mains are 200 mm.

To assure sufficient water, two or more Primary feeders are run by separate routes from the source of supply to higher value and industrial districts. Secondary feeders are arranged in the grid to allow supply from two directions to any point in the system. This practice increases the capacity of supply at any given point, and even if a repair were in progress, a supply of water is assured. Under normal conditions, all points are able to pull water from more than one direction for higher flow rates.

4. WATER MAIN VALVES

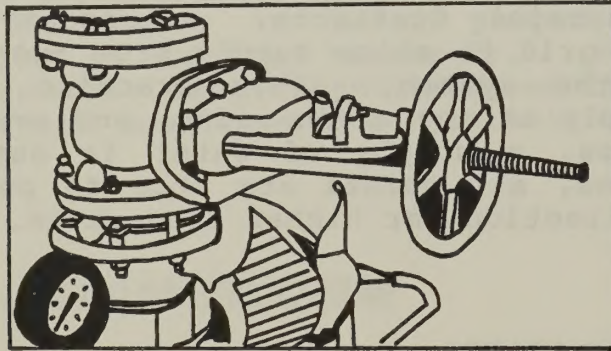
These are a means of controlling flow through the distribution system. Valves are located at frequent intervals in the grid system, so that only small sections of the distribution system need be shut off when making repairs or to stop the flow at a given point in the system. Valves are operated periodically to keep them in good working order.

Types of valves that are commonly in use are the (PIV) post indicator valve, OS&Y and the non-indicating type. Private fire protection systems would use the PIV which is a hollow metal post attached to the valve housing. The valve stem is inside of this post and the words "open and shut" are printed so that the position of the valve is known.

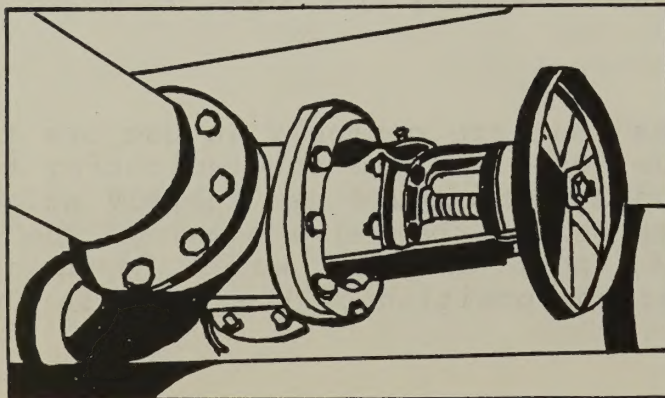
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Valves in public water systems are of the non-indicating type and are normally buried or installed in manholes, and are either gate valves or butterfly type valves.

The Outside Screw and Yolk (OS&Y) is another type of indicating valve and is normally a control valve for a sprinkler system. This valve has a yolk or a large "wheel" on a long threaded stem. When the threaded portion of the stem is out of the yolk or protruding, the valve is open. When the stem is inside the yolk, the valve is closed.

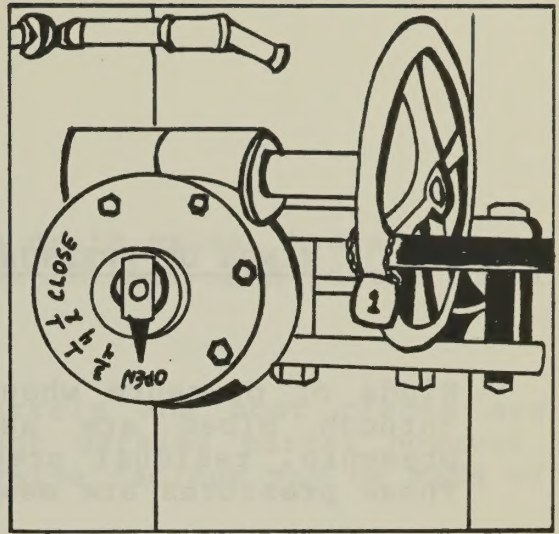
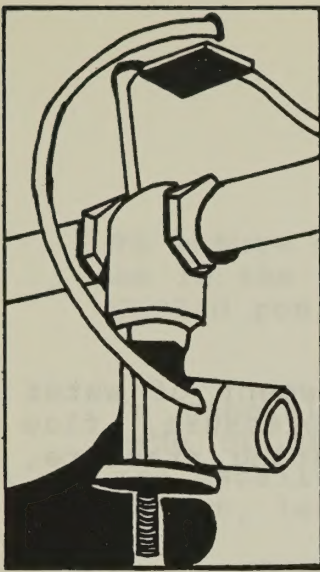


The OS&Y (outside stem and yoke) valve is a common indicating valve for private fire protection systems. The extended threaded stem indicates an open valve.



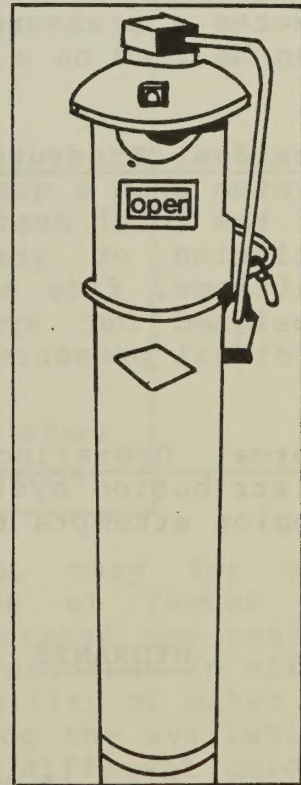
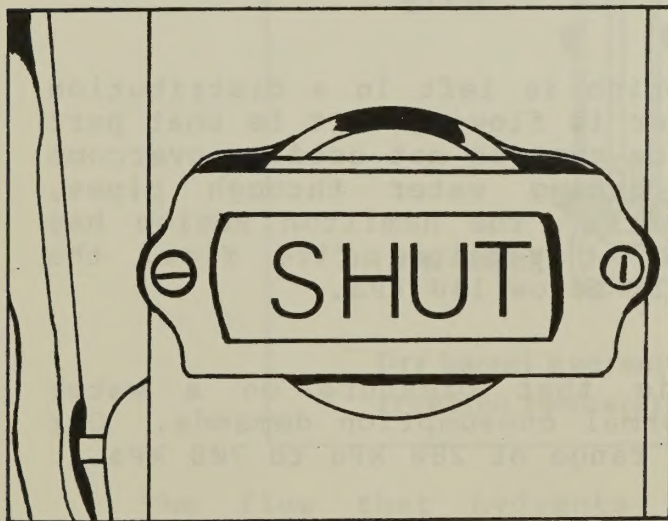
When this wheel is turned to close an OS&Y valve, the stem retracts. The ease of closing this valve makes it subject to tampering.

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Valves can be secured with chains, or a better way is to maintain constant electronic surveillance of valve position.

this indicating valve can show when the valve is only partly open.



The PIV shows the valve's position through a window. The lever arm should be locked to prevent tampering. It is advisable to attach notices of what systems the valve controls.

The post indicator valve (PIV) is connected to an underground gate valve.

(1986)

5. KINDS OF PRESSURE

Kinds of pressure when dealing with the movement of water through pipes are as follows: Static pressure, flow pressure, residual pressure and normal operating pressure. These pressures are measured in kilopascals.

Static Pressure - when the water is not moving the pressure exerted is said to be static. Static pressure is stored potential energy that is available to force water through pipes, fittings, fire hose and adapters.

Flow Pressure is the forward velocity of a water stream that exerts a pressure at an opening (nozzle for example) which can be read on a Pitot gauge.

Residual Pressure is that which is left in a distribution system when a quantity of water is flowing. It is that part of the total available pressure that is not used to overcome friction or gravity when forcing water through pipes, fittings, fire hose or adapters. The Hamilton Region has designed our system so that at required fire flow, the residual pressure will not fall below 140 kPa.

Normal Operating Pressure is that pressure on a water distribution system during normal consumption demands. Our Region attempts to maintain a range of 280 kPa to 700 kPa.

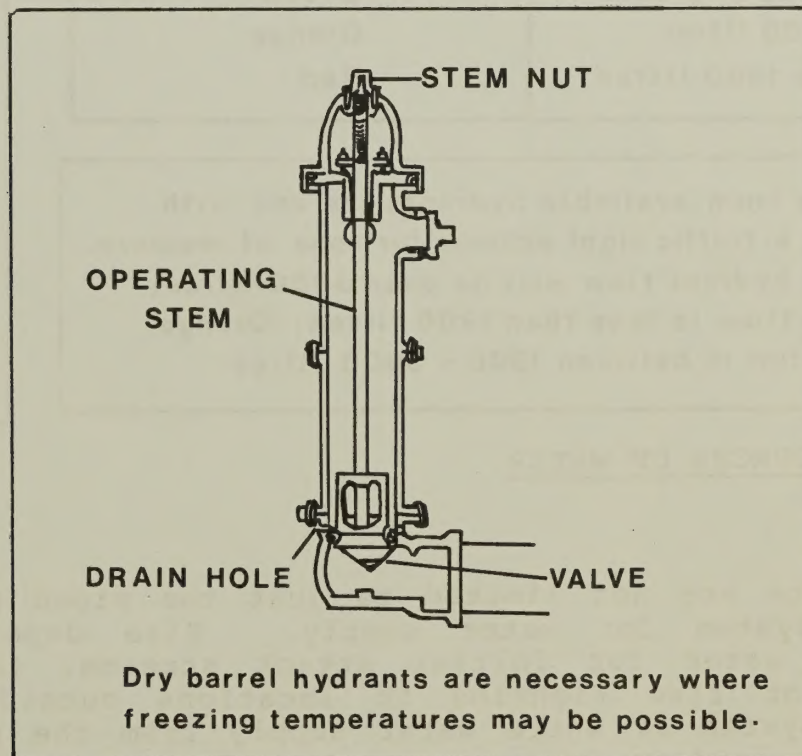
6. HYDRANTS

In the City of Hamilton, only "Dry Barrel" hydrants are in common usage. The dry barrel hydrant is usually classified as a compression, gate, or knuckle-joint type which either opens with the pressure or against pressure. Any water that may remain in a closed dry-barrel hydrant will drain through a small valve at the bottom. This drain valve opens as the main valve approaches the closed position.

(1986)

To ensure proper operation of the drain valve, hydrants must be in the FULLY OPEN position when in use, and in the FULLY CLOSED position when not in use.

In general, hydrant bonnets, barrels and boot pieces are made of cast iron. The important working parts, however, are usually made of bronze, but valve facings may be made of rubber, leather, or composition.



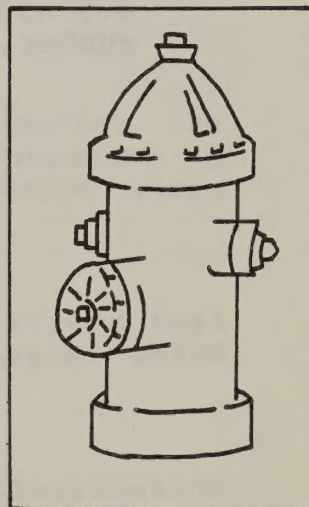
The flow that hydrants will provide, vary for several reasons, such as, size and location of feeder mains. Deposits and incrustations may also increase the resistance to flow. Firefighters can make better decisions in affecting a fire attack when the relative availability of water in the area is known. To aid us in determining the available flow from a given hydrant, they are painted different colours to indicate the size of the main which is supplying them.

(1986)

As of 1981, it became law in Ontario, as indicated in the Ontario Fire Code that uniform marking of hydrants be implemented. Our Region has always had colour coded hydrants and we conform completely with this requirement. The following is the most current information on the marking of hydrants.

Class	Flow	Color of Bonnets & Caps
A	3800 Litres or greater	Green
B	1900 - 3800 litres	Orange
C	Less than 1900 litres	Red

Firefighters can pick from available hydrants the one with the best flow, using a traffic light scheme for ease of memory. Green means go, the hydrant flow will be over 3800 litres; Red means stop, the flow is less than 1900 litres; Orange means caution; the flow is between 1900 - 3800 litres.



7. OTHER SOURCES OF WATER

Fire departments are not limited to just the piped public distribution system for water supply. Fire department pumpers carry water for initial attack streams, tankers carry water for fire fighting in locations outside the public water system or where water supply from the public water system is inadequate.

In addition, it should not be forgotten that water can be drawn from other sources such as lakes, ponds, rivers and even swimming pools.

NOTE: FOR ADDITIONAL INFORMATION REFER TO THE I.F.S.T.A. MANUAL.

(1986)

CHAPTER 16

SEARCH AND RESCUE

1. INTRODUCTION

Rescue in the Fire Service is the safe and rapid removal of persons from places of danger to places of safety with due consideration for any possible injuries. Search and Rescue work is a primary responsibility for all Fire Department personnel, particularly those that are likely to be the first to reach the scene. Essential factors are to search quickly and thoroughly under the direction of an Officer and avoid any duplication of effort.

2. ESSENTIAL REQUIREMENTS FOR SEARCH AND RESCUE PROCEDURE

Searching a fire building for trapped occupants frequently means that Firefighters are themselves subjected to hazardous conditions, and personal safety and protection must be given first consideration. Always remember that if a Firefighter becomes a casualty, he becomes just one more person requiring rescue with one less rescuer available.

- a) Self contained breathing apparatus and full protective clothing must be worn.
- b) Forcible entry tools.
- c) Should have a hand torch.
- d) Life line - if large building.
- e) Portable radio can be very useful during Search and Rescue operations.
- f) Chalk (other suitable way to mark area searched).

(1986)

Must work in pairs, two men can handle a casualty better than one, or if one Firefighter has an accident, the other can provide assistance or go for help.

Firefighters should do a rapid size up by examining a dwelling in three areas; exterior clues to interior layout, dangerous features under fire conditions, and the Search and Rescue problem.

Determine point on which to enter the building. This will depend on the location and intensity of the fire (or other active hazards). Before entering the building try to find out how many (if any) people are inside the building and their possible location. Look for signs of possible occupancy, i.e. car in garage, child's bike on lawn, etc. If possible, enquire from neighbours. In all cases, maintain self control and think before you act while searching.

3. TWO STAGES OF SEARCH - PRIMARY AND SECONDARY

Primary Search

Initially attempt to locate any occupants that are in the greatest danger. Time is of vital importance, search must be carried out as quickly as possible. A co-ordinated procedure is necessary to assist searchers, including charged lines, ladders where needed and ventilation of search areas. The fire floor and the floor immediately above the fire floor present the greatest danger. Both these primary areas should be searched first, simultaneously if possible. Initially search the most likely areas where people may be found. This quite often will be near a means of exit, particularly close to the main doorway, stairs, or windows. If at night, quickly check bedrooms of residences. Of course, if an occupant has suggested where a person may be, this would receive top priority. After these areas are checked, start a systematic search of all floor areas.

(1986)

Remember men operating on the fire floor must keep in mind the presence of any men on the floor above, if fire streams are unable to hold the fire, instant warning must be given to the men above the fire. Men on hose lines should use direct or indirect attack and maintain thermal balance, think about the rescue crew above the fire.

Secondary Search

Organize as soon as conditions permit, here time is not the most important element, thoroughness is. A secondary search is usually necessary in case of occupants being overlooked because of difficult conditions and the need for urgency. Any place where it is possible for people to hide (or be hidden) must be searched, including debris. Nothing can be taken for granted. Even seemingly vacant buildings could have children or transients trapped inside.

4. STANDARD SEARCH PROCEDURE

A definite plan should be thoroughly understood and followed by all Firefighters. Rescuers upon arriving on the floor to be searched can turn either right or left depending on the circumstances. Either choice is right as long as they turn in the same direction throughout the entire search, i.e. turn right in the hallway; 1st room on the right, turn right, upon leaving the room turn right, continuance of this right turning would eventually return the searcher to the point of beginning.

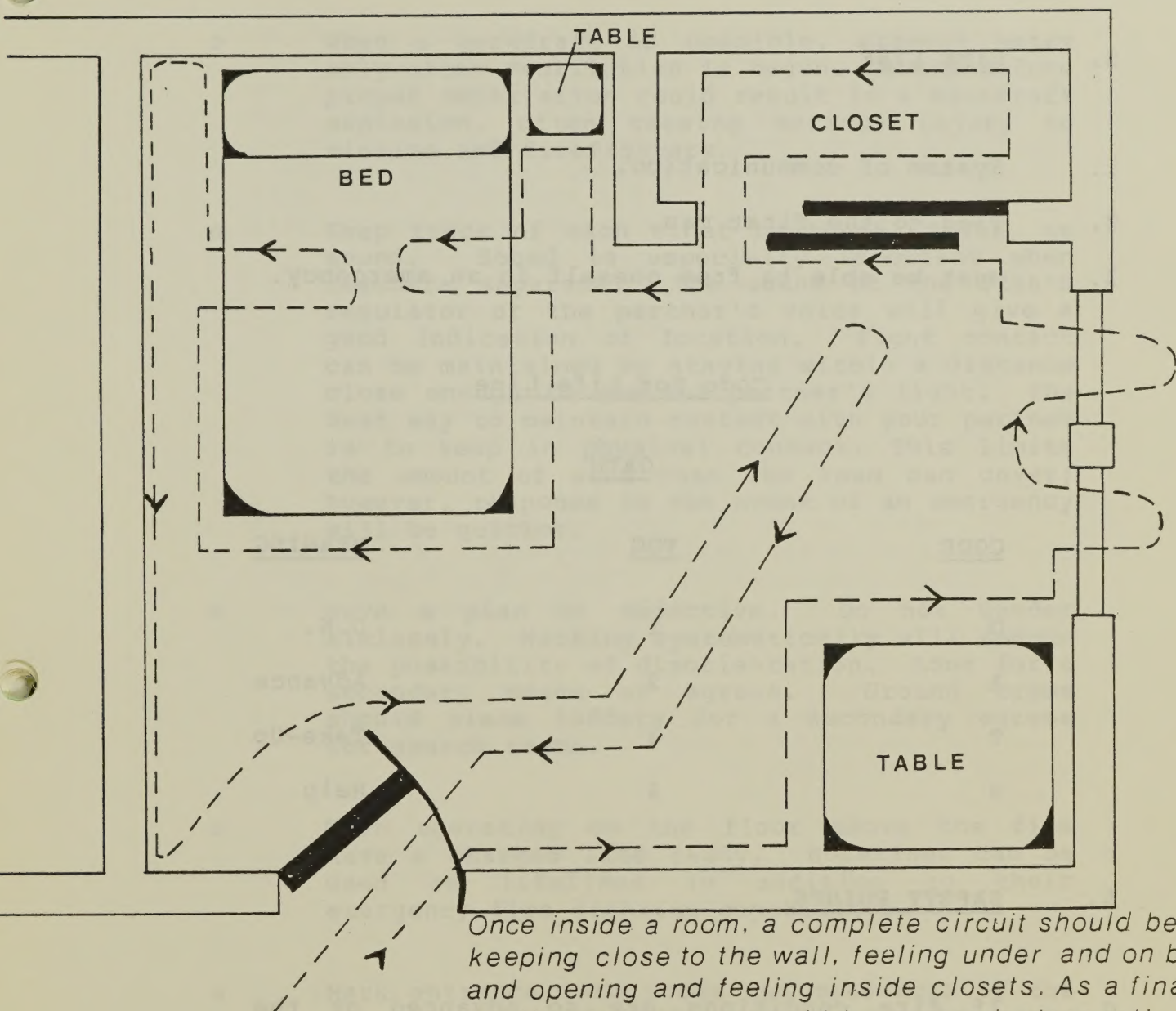
After a room has been thoroughly searched, mark an "X" with a piece of chalk, on the exterior of the door as an indication to other crews that the room has been searched (turn mattress, chair in doorway).

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If visibility is limited, search on your hands and knees, follow walls, open windows to ventilate. Look under beds and behind all furniture. Check all closets thoroughly as children frequently pick these locations in their attempt to hide from fire.

Use arms and legs to sweep back and forth under beds and furniture. Cover open floor area, especially if visibility is limited. Pause occasionally to listen for crying, coughing, moaning or other sounds which may indicate the presence of trapped occupants. Searchers must be able to anticipate situations in which they will find casualties. Operations should be initially directed to rescue people who can be seen and heard, or those whose exact locations are known. Searchers must relay all relevant information to the Officer in charge.

(1986)



Once inside a room, a complete circuit should be made, keeping close to the wall, feeling under and on beds, and opening and feeling inside closets. As a final precaution the room should be crossed diagonally to make sure that no one is lying in its center.

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5. LIFE LINE

1. System of communication.
2. Tied to the first man.
3. Must be able to free oneself in an emergency.

Code For Life Line

OATH

<u>CODE</u>	<u>TUG</u>	<u>MEANING</u>
O	1	O.K.
A	2	Advance
T	3	Take-Up
H	4	Help

6. SAFETY POINTS

- o If fire conditions are so advanced or the condition of the building is so poor that rescuers have a good chance of losing their lives, rescue should not be attempted. Under such conditions it is unlikely the victim would be alive.

(1986)

- o When a backdraft is possible, attempt entry only after ventilation is begun. Entry before proper ventilation could result in a backdraft explosion, often causing serious injury to victims and firefighters.
- o Keep track of each other by touch, sight, or sound. Sound is especially important when rescuers separate. The sound of the SCBA'S regulator or the partner's voice will give a good indication of location. Sight contact can be maintained by staying within a distance close enough to see the partner's light. The best way to maintain contact with your partner is to keep in physical contact. This limits the amount of area that the team can cover; however, response in the event of an emergency will be quicker.
- o Have a plan or objective. Do not wander aimlessly. Working systematically will reduce the possibility of disorientation. Look for a secondary means of egress. Ground crews should place ladders for a secondary egress for search teams.
- o When operating on the floor above the fire have a charged line ready. Hoselines can be used as lifelines in addition to their emergency fire fighting capability.
- o Mark entrance into rooms and make note of the direction turned while going into the room. To exit and return, turn in the opposite direction.

(1986)

- o Feel door handles or knobs with the back of an ungloved hand before advancing through doors. A hot handle is a good indicator of fire on the other side of the door, open the door cautiously. Don't stand in front of the door. Stay to one side, keep low, and open the door. If there is fire behind the door, this will allow the heat and combustion products to pass overhead.
- o If a door opens easily at first then is stopped by something, reach around the door to determine whether the obstruction is an unconscious person. When probing with a tool use caution to avoid injuring the victim.
- o If entry is to be made through a window, be cautious when breaking glass, an unconscious person may be on the other side. First probe for possible victims and then check the floor for stability before entering.
- o Inform the person in charge if an entrance is blocked, or if a search cannot be made because of heat, smoke or fire.
- o Close the doors of fire-involved rooms to help contain the fire, call for a hoseline and continue the search.
- o Crawl on hands and knees when visibility is poor.
- o Stop frequently and listen for evidence of victims: coughing, moaning, crying.
- o Stay low and move cautiously.

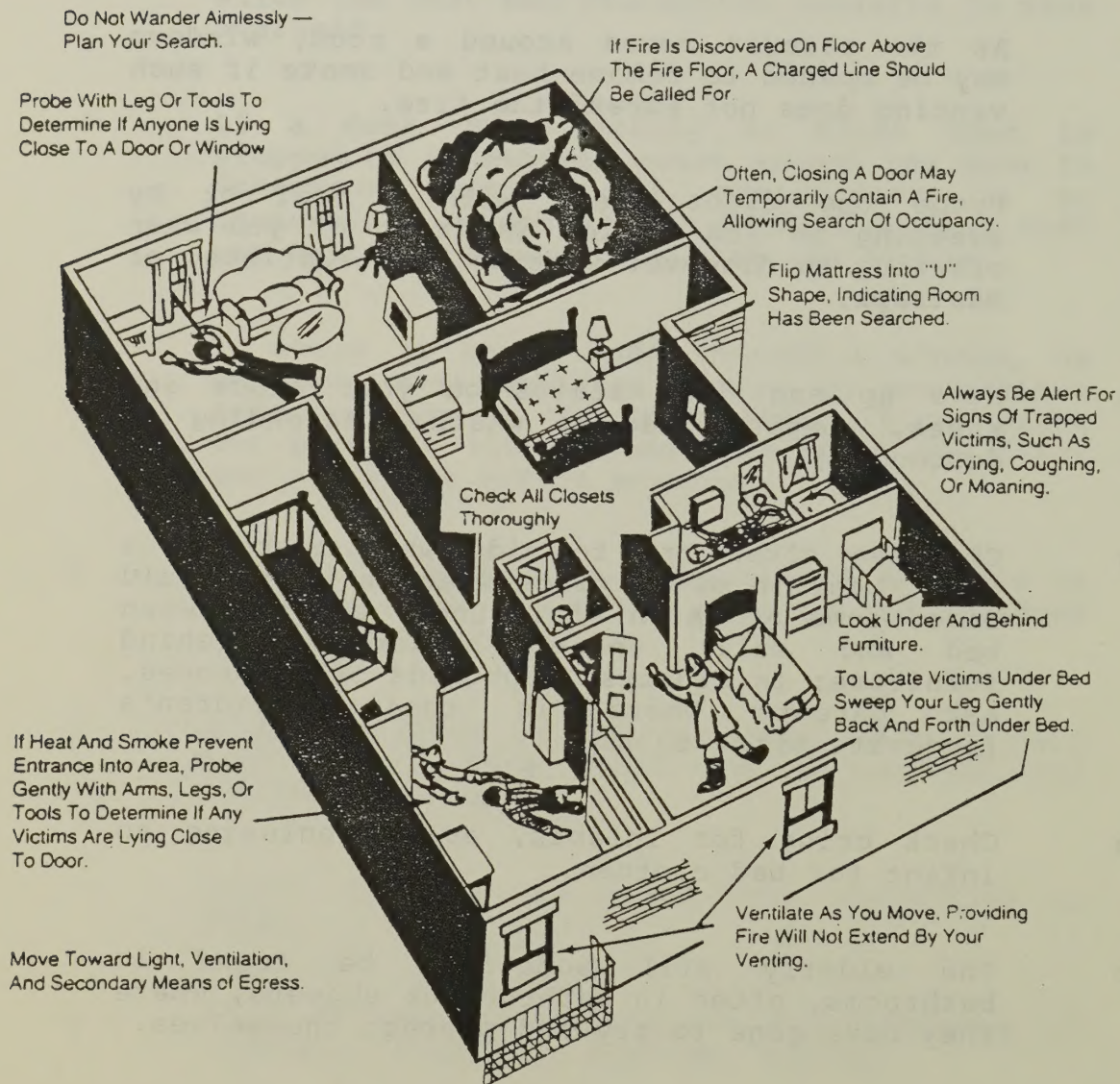
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- o Watch for hot spots, weakened structures, and other indications of fire extension.
- o Keep in contact with a wall. Ropes or straps can extend the coverage between two rescuers.
- o As the rescuer moves around a room, windows may be opened to remove heat and smoke if such venting does not extend the fire.
- o Probe the floor ahead with a tool or by sweeping an arm or leg in front of you when crawling to discover victims, obstructions, or mantraps.
- o Move up and down stairs on your hands and knees, keeping head up whether ascending or descending.
- o Children often try to hide when there is a fire. Look in every place where a child could hide, some of which are: Under beds; between bed and wall; under, beside or behind furniture; in closets, cupboards or wardrobes. Ask parents where is their children's favourite place to hide.
- o Check cribs for infants, avoid confusing an infant for bed clothes.
- o The elderly will sometimes be found in bathrooms, often in bathtubs or showers, where they have gone to try and protect themselves.
- o Check around all exits such as doors, windows, elevators, stairways, and hallways. Adults will usually try to escape from a building by routes they normally take. They are often overcome in these areas.

(1986)

- o If S.C.B.A. malfunctions or depletion of air supply, stay low to floor, place the end of breathing tube in the arm pit under turnout gear, or place face close to a fog stream.

Searching Hints



NOTE: FOR ADDITIONAL INFORMATION REFER TO I.F.S.T.A. MANUAL.

(1986)

CHAPTER 17

ARSON

THE FIRE SERVICE RESPONSIBILITY IN DETERMINING THE CAUSE OF FIRES AND FIRE CRIME DETECTION

1. INTRODUCTION

It is the responsibility of the fire department to conscientiously try to establish the cause of every fire. Firefighters are in the best position to determine the point of origin of fire and establish fire cause. First of all, they are normally among the first to arrive on the scene and can see the location and progression of fire in its early stages. They can see the type of occupancy; what part of the building is involved and will recognize whether there is a normal or abnormal spread of fire. They will know the amount, condition and location of furniture, clothing, stock and equipment etc, in the building. They can establish whether doors or windows were locked or open, and will know what doors or windows were forced to gain entry. They will find evidence in its original state, untouched and undisturbed and can talk to witnesses on the scene while facts are still clear in the witnesses' minds. These observations, the witnesses' statements, along with a physical examination at the point of origin will establish the fire cause. By establishing the true cause of every fire, fewer incendiary or suspicious fires will go undetected and therefore, uninvestigated.

Determining the cause of fire begins the moment the fire alarm is received. Record the exact date, time, and type of alarm. Get the name and address if possible of the person putting in the alarm, the person's attitude, and establish the nature and cause of the emergency.

2. ENROUTE TO THE SCENE

While enroute to the fire scene, note the weather conditions, what route you took, the wind direction and any obstructions.

3. ARRIVAL AT FIRE SCENE

Note the exact time of arrival, observe the height and construction of the building or buildings involved, as well as their occupancies. Note the direction the building faces, the direction of approach of your apparatus. What part of the building is involved, and through what window or door did you observe the fire. What are means of entry, and the direction of fire travel.

Once the fire is extinguished, delay the start of overhaul operations until you are satisfied that a reasonable cause has been determined. I say reasonable as it may not be possible to interview all witnesses at the scene who may have some knowledge as to the cause; however, a physical examination should be made, available witnesses be interviewed to come up with a reasonable cause. While at the fire scene, persons who were home at the time of the fire, and witnesses, should be questioned, as more factual information is available while the circumstances are fresh in their minds. The discoverer of the fire is an important witness because; he may be able to state where the fire was located at inception; he may be able to describe the direction of spread of fire; from his observations, you may be able to locate physical evidence when you search the fire scene. Ask simple clear questions to establish:

1. Who discovered the fire.
2. Who turned in the fire alarm.

(1986)

3. Was anyone present when the fire started.
4. When and where did it start.
5. What was happening when the fire started.
6. The observations of the witness.
7. Do the witnesses know the cause of the fire.

Using this formula, along with your physical examination at the scene, you will be able to establish a reasonable cause for the fire.

4. DETERMINE POINT OF ORIGIN

To establish the cause of a fire, we must first find the point in the building or structure where the fire started, or in other words, the point of origin. To do this, we must locate the lower point of burning in the building with the greatest amount of charring. As fire normally burns upwards, a fanning out effect or path of fire can be found. The base of such pattern is the point where the fire began. We must remember that fire will travel on a horizontal plane or even burn downwards through flooring or walls to reach a source of oxygen. Fire will follow the path of flammable liquids or combustible materials. Generally the room or area with the greatest amount of charring or damage is the area where the fire originated. This must be tempered with common sense in remembering that the area where the fire originated may have been easily accessible by the fire fighter and extinguished, however, the fire may have progressed into another area that is not as easily accessible by the fire fighter and would burn a longer length of time before being extinguished. This area would naturally have a greater amount of charring and heat damage. More combustible materials in one area of the building could also result in more damage in a particular area.

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5. FIRE SPREAD

Fire and heat may spread throughout the building either by conduction, convection or radiation. There can be an intense fire in the basement and as heated gases rise to the highest point in a building, the hot gases will ignite combustible materials with no apparent connection between the two points. Several things must be kept in mind of course, i.e. what combustibles were present, their ignition temperature and an estimate of the probable temperature build-up from the super-heated gases which had risen through the openings to the upper levels. Most fires burn upwards and seek their own vents, such as stairwells, elevator shafts, laundry chutes, dumb waiters, etc. By locating and examining the fire pattern, we can trace backwards to the point of origin of the fire. Fire will travel vertically up the outside of a concrete and brick building, floor by floor, via windows and not spread horizontally floor by floor.

Fire can spread horizontally between floor joists; between ceiling and floors; through attic or cocklofts; along beams; through brick or block walls; through furnace ducts; and by flying embers or debris.

6. FIRE BURNS UPWARDS

When combustion starts, air pressure rises, hot gases and flames go to the upper parts of the enclosure until they find holes, breaks, etc. through which they can escape and new fresh air can be sucked in. If there are normal outlets for these gases, combustion becomes rapid. Preheated gases and fire, unobstructed and under normal conditions, always travel upwards seeking the highest point. The ceiling directly above the point of origin could be discoloured, charred or even burned through.

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7. EXAMINATION OF PHYSICAL EVIDENCE - REPLACE FURNITURE

Any combustible materials such as furniture, walls, baseboards, floors, etc. will be more heavily charred or damaged at the closest exposure to the fire or heat. It may be necessary during fire fighting operations, to move or remove furniture from a certain area to extinguish the fire. If the furniture has been removed, it is necessary that the owner, tenant, or someone familiar with the location of furniture be present to show you the exact location of the furniture prior to the fire, or what combustible materials were present. If furniture has been removed after the fire, you may be able to observe areas of protected burning on the walls, floor areas, etc., of course taking into consideration the amount of burning and this will give you an idea of where certain furniture was located at the time of the fire. Examine the floor area. By this method, it is possible to reconstruct the furniture by locating the leg impressions indented on rugs or linoleum or tiles. The sides, front, back, top and underside of furniture should be examined to find where the most extensive fire or heat damage occurred. Normally, we do not get the underside of chesterfields or chairs burned. Any burning of this nature could indicate the fire had originated near or under these articles. The baseboard, quarter round, floor and doorways, door jambs, and window sashes have to be examined to establish from what direction the greatest amount of heat and flame did emanate from.

8. DISSECT AREA

The general area of fire should be dissected, and mentally split in half, or if a diagram is made, the diagram should be cut in half and dissected to eliminate areas of little or no burning.

This process of elimination should be continued until you come up with the heaviest burned area. You may find that one side of the chair is burned but the other side is free

(1986)

of burning. This, then will give you a direction from which the fire had originated. By examining the windows, it is very easy to establish whether they were closed or opened. By examining the doors and door jambs, you will be able to establish whether or not the doors were open or closed at the time of the fire. If the door is closed, and you have a definite heat pattern throughout the ceiling and wall area, then the damage on the door on the inside of the room should correspond with this damage on the walls. If the door was open and against the wall, you will find a pattern on the inside of the door, going in an upward sweep. If the door is open, the outside or back of the door and the wall behind it, will be protected. It is common sense to realize that if a door is closed, the inner part of the jamb should be protected by the door itself and be free of burning. If a door or window is open, the fire pattern will show a direction to the opening as fire will reach out to get at a source of oxygen. However, it must be established whether or not fire, or police personnel, or even witnesses opened the door or window while the fire was still burning. This could drastically change your opinion of the path of fire and the position of the door or window at the time the fire originated.

9. FLOORS - SIMILAR COMBUSTIBLE MATERIALS

Examine similar combustible materials or metals in the room. If there are two exact types and compositions of combustible materials or metals and one is more heavily charred or melted than the other, it is obvious then where the greatest amount of heat was located. Normally we do not get a lot of heat or charring all over the floor area, as we know all flame and heat usually goes to the ceiling and fills up from the ceiling downward. Examine the floor, baseboard and quarter round to locate the lowest point of burning in the room. If the flooring is charred, thoroughly examine this area. On several fire scenes we have examined, we have found where the walls and even roof area have completely burned through, however, we have found that the floor area such as hardwood flooring, rugs, linoleum, etc., had been relatively untouched by fire. If you find this condition

(1986)

existing then it is reasonable to assume the fire was of a high burning nature in the room, and started above floor level. Examine the layers of burned debris to establish what burned first, i.e. charred newspapers found on the floor beneath charred drapery material.

10. ROOM SEALED - SMOULDERING MASS

Normally, we do not get too much burning in the lower areas of the room, however, we will if the fire originates in a room that is closed or sealed and the fire changes from open flame to a smouldering mass due to a lack of oxygen. Under these conditions, the fire will either extinguish itself or because of a large build-up of heat will char everything in the room including the floor, and you will find no definite fire pattern.

11. FLASH FIRE

If you have a flash fire in the area caused by the ignition of a flammable vapour, you could also have a searing or charring effect all over the room right down to floor level.

12. OXYGEN

By the physical damage that has occurred in the building, it is very easy to establish whether or not there was a lack of, or a good supply of oxygen in the building which was caused by all doors and windows being closed, that the walls and ceiling area and general condition throughout the dwelling will be covered with a heavy deposit of soot. It is not abnormal in these conditions to find that if a fire had originated in a chesterfield or chesterfield chair,

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that the fire, due to lack of oxygen, turned into a smouldering mass and burned the direct imprint of the chesterfield or chair, right down through the hardwood flooring, subfloor and joists, and the springs have dropped into the basement or floor below and has not damaged a table or other piece of furniture nearby.

13. CURTAINS

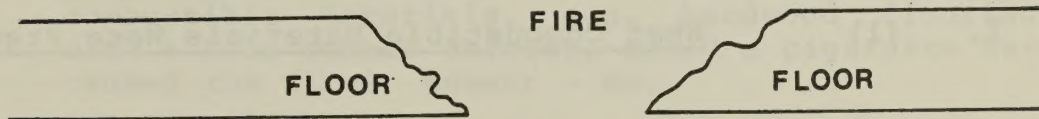
You may find the appearance of different points of origin of fire, in that the floor area is charred underneath each window. By checking further, you will probably find this was caused by the curtains, which, when caught on fire, dropped down to the floor area or on the furniture and started another fire. This could also spread the fire. It is well known by all fire investigators that fire and heat travel upwards and once they hit an obstruction, such as ceiling, will fan out across the ceiling area. By examining open frame joists, you will find that one side of the joists is more deeply charred or burned than the other. By tracing back, you will find that the direction by which the fire had come across the ceiling, directs you to the point of origin of the fire.

14. BURNING THROUGH FLOORS

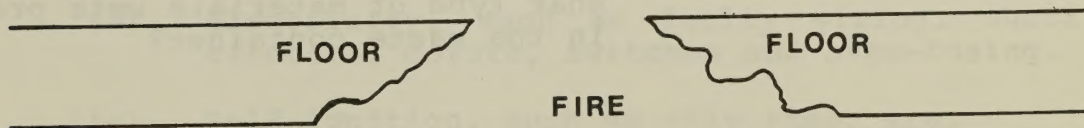
If you are not sure during your physical examination whether the fire had burned upwards from the basement into the first floor, through the flooring, or whether the fire had originated on the first floor and burned downwards into the basement, by examining the hole burned through the floor, you might remember this:

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That if the fire had burned downwards, this type of fire pattern will generally be found.



That if the fire had burned up through the flooring, this type of pattern will be found.



15. DROP BURNING

Fire will spread from one section of the building to another, as a result of drop burning. Fire will burn through the floor, and debris will drop down to the floor below and ignite combustible materials, starting a fire in that area.

Once you have established the point of origin, you must ask yourself these three questions:

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1. What combustible materials were present?
2. What is our ignition source?
3. What was the oxygen supply?

1. (1) What Combustible Materials Were Present

Were the materials normal to the occupancy or foreign? If they are normal to the occupancy, is the material in its normal position? Is this a logical position for the combustible materials to be located? (Newspapers in living room as opposed to five gallon can of gasoline in living room). What is the ignition temperature of the combustible materials?

Waste container fire: What amount of combustible materials were present?

What type of materials were present in the waste container?

(II) Flammable Liquids and Vapours

Not all fires caused by the ignition of a flammable liquid are incendiary. Accidental fires are caused by the careless handling of gasoline or by using a volatile adhesive etc. If there is an accidental spillage you will usually find evidence of gasoline in its raw state. However in these cases you should find the container. Normally gasoline is kept in a garage or work shop area of a residence; and should be found in these locations. A container found in a living room should be viewed with suspicion. Flash fires or explosions can result from the ignition of flammable vapours, just from open containers. In this case an entire area will be evenly burned, with the heaviest fire damage at the source of the vapour.

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2. What is Our Ignition Source

You must establish what ignition was present at the point of fire origin and is the temperature of your ignition source high enough to ignite the combustible materials, e.g. hardwood flooring, with a hole burned through, could a cigarette have caused the fire? Answer - No.

However, If combustible materials are present such as newspapers, cloth, curtains, etc., then a cigarette could have set fire to the materials causing a fire.

The following sources of ignition heat should be considered:

- (a) Flames, sparks, radiated heat from stoves, furnaces and other heating appliances or their chimneys.
- (b) Electricity, such as faulty wiring, short circuits, motors, switches and over-fusing.
- (c) Self-ignition, such as oily rags, etc.
- (d) Carelessness with cigars, cigarettes, pipes, matches (and children).
- (e) Lightning, etc.

If a cigarette is suspected as the ignition source, establish:

- (a) Who was the last known person in the area of the point of origin of the fire.
- (b) Does this person smoke.
- (c) Was this person smoking.
- (d) The time lapse between the time the person had left and the discovery of the fire.

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- (e) The amount of fire when first discovered.
- (f) What combustible materials were present at the origin of fire that could have been ignited by a cigarette.

If a heating device is suspected, establish when it was last used. Examine the drafts to see if they were open or closed; are there any ash or residue left in the stove or unburned wood; the stove pipes whether they are in good condition or have holes in them; or are they full of soot. If a chimney fire is suspected, check for cracks or loose bricks and mortar, etc.

3. What was the Oxygen Supply

Was there a normal source of oxygen for the fire, or were windows or doors, etc., deliberately left open? (Windows open in the summer would be normal. Windows wide open in the winter could be suspicious).

Important: Establish from the owner or occupant, whether the building was securely locked or if any doors or windows were open. This can be compared with the condition of the doors and windows at the time of your arrival.

Accidental causes of fires are numerous. A thorough knowledge of these fire causes, recognition of their characteristics, common sense, corroborating physical evidence, and witnesses' statements, will establish the true cause of a fire.

16. TOTAL LOSS FIRES

Up to now, we have been dealing with a type of fire that results in only partial destruction. The total destruction

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of a building offers a more difficult problem for a number of reasons. All that remains is a pile of burned and charred materials. This type of fire occurs mostly in country areas that have little or no fire protection, but certainly it could happen in the city. In this case, the only hope you people in the fire service have of determining the cause of this type of fire is by the questioning of witnesses, starting with the tenant, the last person in the building and the person discovering the fire.

17. STATISTICS

For statistical purposes, it is not necessary that you can actually prove that a fire started from a certain cause, what is required is your opinion based on a careful examination of the fire scene, and if possible, corroborated by witnesses.

18. WHAT IS A FIRE CRIME

Unlawfully setting fire to any property is a fire crime. Wilfully is interpreted as intentionally, deliberately or knowing the probable results, recklessly. In this definition, the word "arson" simply means that a person cannot wilfully set fire to another person's property, nor can he set fire to his own property for a fraudulent purpose. In this definition, the words "set fire to" mean that there must be actual combustion, although it is not necessary for the material to blaze openly, so long as it comes to a red heat. Charring is evidence of burning, but blackening of a material not accompanied by any degree of consumption is not, nor is mere scorching.

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19. WHAT FIRES DO THE FIRE MARSHAL'S OFFICE INVESTIGATE

In the Province of Ontario, responsibility for fire investigations has been retained by the Province and the Fire Marshal's Act sets out specific duties in that regard. The Fire Investigation Services investigates those fires that have been determined by some responsible person to be of incendiary origin, or those of undetermined origin where there is suspicion of a criminal offence having been committed, as well as fires and explosions where there is loss of life or property damage of \$500,000 or over. Other than the large losses, we do not investigate simply because the cause is undetermined.

20. HOW CAN THE OPERATIONAL FIRE FIGHTER ASSIST THE FIRE MARSHAL

Observation is one of the main ingredients in detecting the suspicious or incendiary fire. On your arrival at the fire scene observe:

(a) Size of Fire

The size of the fire should be noted by the members of the fire department. The rapidity of flame spread, from the time the fire was discovered until the alarm was received and the arrival of fire fighters at the scene of the fire, may have a direct bearing. Inquiries should be made as to whether or not any unauthorized persons were observed in the vicinity of the fire at the time of discovery.

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(b) Observe the Occupants

Often times when firefighters arrive at the scene of the fire, other persons are present. The firefighters should make mental notes of the way the persons are dressed, their mental demeanor, and other pertinent details which might be of importance in later assessment when all available facts are considered. Observe any person or automobiles hurrying away from the scene of a fire. If possible get the licence number of such automobiles. Careful mental notes of identifying characteristics of persons and vehicles should be made. Compare such observations with similar observations which may be made by other firefighters at the time.

(c) Means of Entry

Keep a mental note in how you entered this building as prosecutions of an arson case are difficult if the fire fighter, because of stress or excitement, is unable to state what door or window he used. Remember whether it was locked or unlocked. The fact that the doors were locked or padlocked may have a direct bearing upon the case later. The first firefighter in the building should observe whether he was the first person to enter, or whether someone had entered the building prior to his arrival. The possibility of outsiders gaining entrance before the arrival of the department is often very important in the case.

The condition of doors, door jambs, window sills and the kind of lock is often very important and might indicate burglary followed by arson to cover the crime.

Doors or windows opened, closed, or locked may have a valuable bearing upon the case. It might indicate forcible entry, or it might indicate the desire to create a draft. Window drapes may be closed, or materials placed over windows to delay detection of the fire. In any event, the information is quite likely to be valuable and in recognition of evidence in arson cases, should be taken into account.

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(d) Number of Separate Fires

As all fires are presumed to be accidental until proved otherwise, the presence of multiple fires overcomes the presumption of accident and is sound evidence of intent to destroy the building. Fires are set in widely separated places and sometimes the fire contains a trail between each point. Tissue paper or other combustible material which will burn readily is generally used. Thus, separate fires which extend sometimes from the basement to the attic, leave a trail of fire in all rooms and hallways enroute.

Other means are employed to hasten the destruction of the building by boring or chopping holes in plaster, through the floor and using other methods to ventilate the fire, thus, creating a draft which tends to spread the fire more rapidly, micro-film, bed sheets, paper and flammable liquids are used to spread the fire from one area to another.

Fires may spread to another location in a building legitimately, by convection, conduction or radiation, and through vertical openings spreading to upper floors. The fire fighter must be able to differentiate between the accidental and the intentional spread of fire throughout the building.

(e) Intensity of Flame

The intensity of the heat generated by the fire often indicates that some fuel has been added to the normal contents of the building. This condition, of course, should be a valuable indication to the firefighter that flammable liquids or compounds have been used to spread the fire more rapidly.

The application of flammable liquids and petroleum products to wood will also cause a deep undue burning. Char marks of petroleum products poured upon the floor will burn in the pattern of the liquid and sometimes

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it runs in the cracks and burns underneath the floor upon which it was applied. Look for containers as they are used and left on the premises, the fire that burns around these containers generally chars the wood leaving a bare unburned place in the spot where the container stood.

Uneven burning sometimes indicates the application of a flammable substance but falling drapes, curtains and clothing sometimes create the same impression and firefighters will have to be very careful in their assessment.

(f) Difficulty of Extinguishment

Sometimes when hitting such fires, set with petroleum products, with fire streams, instead of the fire going out as might be presumed, the fire will burn with greater intensity and with different colour flame.

Red flames are evidence of petroleum products as a rule. Blue flames generally indicate a small amount of alcohol, and orange flames most generally indicate a large amount of alcohol. Flashbacks are somewhat common when hitting these fires with fire streams, and should fire appear on top of the water you can rest assured that you are confronted with a highly flammable substance.

(g) Odours

The odour emitted from various fires is important. Almost everyone is familiar with the odour of gasoline. Kerosene may be confused with solvent. Alcohol has a distinct odour as do various chemicals. Sulphur candles - sulphur odour - leave coal black glistening mass of molten residue. Films, toilet articles and other nitrocellulose pungent camphor odour - leave fibrous residue. Phosphorous - odour of match heads -

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leave coating on tongue when inhaled - leave a brownish red residue with many bubbles. Carbon bisulphide - rotten cabbage odour - leave no residue. Moth and insect sprays - sweet and perfumed.

(h) Delay Ignition

Candles and similar materials containing wax or paraffin are often used. Where suspected look for residues on floors, tools or appliances.

(i) Condition of Contents, Whether Disarranged or Removed

Persons plotting a fire sometimes remove from the building or residence those things which are of personal value - to which they attach some sentimental value. They also sometimes remove their fire insurance policies and other papers of a business value. Entire contents of stores and residences have been removed to a different location and different contents of lesser value or no value whatever have been placed in their stead to give the appearance of having been destroyed.

It is not uncommon for the firefighter to find contents of drawers strewn over a floor, bureau and desk drawers open, and many times closet doors are blocked for the purpose of exposing their contents to fire and thus destroy them. Fire doors are left open in some places and the placing of obstructions to keep them from operating is sometimes used. It is a simple matter to interfere with the weights of the fire doors of the fusible links so as to aid in the ventilation of incendiary fires, and allow fire to spread from one area to another.

(j) Examine Sprinkler Systems and Fire Doors

Sprinkler systems may be tampered with, and supply valves shut off. Wire glass windows and shutters, in openings between walls, are often opened to permit a more rapid spread of fire.

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The alert fire fighter looks about for things that are not present but ought to be. Such observations may prove especially valuable in a household fire which occurs in an apartment or flat. Most people can't resist the temptation to remove their own cherished possessions before starting a deliberate fire. The absence of children's clothing or the mother's toilet articles, the outline of a missing picture on a wall, the disappearance of canaries, cats or dogs from a household in which traces of them still remain. All of these things should awaken instant suspicion. The family bible and grandfather's portrait are high on the list of prized items very often removed.

(k) Obstructed Windows

Many arsonists, to hide their crime, will pin window curtains and blinds down so that their activities cannot be observed while they are starting a fire or making preparations for it, or to delay detection. Papers have been used to obstruct windows. Racks of clothing and other obstructions from the inside of the building are also used. Furniture is placed across doorways to obstruct the entrance.

(l) Familiar Faces and Unduly Interested Persons

Perhaps in no other type of criminal act does the theory that a criminal always returns to the scene of the crime hold so true as it does in arson. On innumerable occasions the perpetrators of arson will be found in the crowd of onlookers at the fire. Because of this, attention must always be paid to the seemingly over-enthusiastic, unduly excited, or visibly interested spectator.

Observation of familiar faces at numerous fires in different sections is food for thought when considering arson. We must take into account the person who is unduly excited and takes undue interest in a fire which

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could not possibly have a financial or material interest to them. Any statements made by suspicious individuals, or any conversations overheard should be paid particular attention to by the fire fighter and the details remembered accurately.

21. PRESERVATION OF EVIDENCE

Where there are suspicious circumstances surrounding the fire or definite physical evidence of incendiarism follow these specific procedures: Two things should be kept clearly in mind by firefighters regarding the protection and preservation of evidence of fire causes:

- (1) Keeping the evidence where it is untouched and undisturbed, if at all possible.
- (2) Properly identifying, removing and safeguarding such evidence that cannot be left at the scene of the fire as it was discovered.

No changes of any kind should be permitted in the evidence other than what is absolutely necessary in the extinguishment of the fire. Photographs are excellent supporting evidence if taken immediately.

(a) Exercise Caution

One precaution which must be exercised by all firefighters during the fighting of a fire is to avoid tramping over possible arson evidence and obliterating it so badly that it is useless. The same applies to the excessive use of water which may produce similar unsatisfactory results.

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(b) Protect Evidence

Evidence remaining at the scene of a fire can be protected in various ways, if and when discovered. Areas containing it can be roped off. Guards can be posted and changed, as necessary to prevent tampering or needless handling of evidence. Leave plenty of room around the evidence to protect it exactly as it was found. Preserve burned or partially burned papers found in furnace, stove or fireplace by eliminating or reducing draft by closing dampers and openings.

(c) Preserve Footprints or Fresh Tire Marks Found at Scene

Protect several feet of discovered tire tracks; and if the car turned around, allowing the print of all four wheels to show, include the place at which the car turned.

Protect human footprints for several yards to allow for measurements of the prints, comparisons of prints, estimate of length of stride, position of feet, and any peculiarities in the gait (walk or run) of a suspect. It may also be possible to secure identifying marks on soles and heels of the shoes worn. Take similar precautions with animal footprints. Boxes placed over prints will prevent dust from blowing over an otherwise clear print.

(d) Fingerprints

Bottles and containers which have been used to carry flammable liquids can sometimes be used to develop latent fingerprints. It is of sufficient importance to protect all such bottles from indiscriminate handling, so that if such prints do exist they will not be obliterated and can be identified.

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(e) Avoid Disturbing or Destroying Evidence

- (1) Use fog with minimum of water where possible.
- (2) Avoid using stream directly on evidence.
- (3) Do not overhaul until fire cause has been established.

(f) Secure the Fire Scene

Once the Fire Chief is suspicious as to its origin, he should immediately take steps to secure the property on which the fire occurred, either by posting guards at all possible places of entry, or by securely locking the premises. The legal value of physical evidence can be rendered useless by the fact that one unauthorized person entered. The Municipal Fire Chief has authority under Section 13 of the Fire Marshal's Act to keep everybody out of a building in which there has been a fire for as long as it is necessary to complete the examination of the premises. His authority is as follows:

- (1) To enter and examine any premises on which he has reason to believe there may be a substance or device likely to cause a fire;
- (2) To close such a premises and to prevent entry thereon by any other person for such period as is required to complete the examination of the premises; and
- (3) To remove from such a premises and to retain and examine any article or material that in his opinion may be of assistance in connection with any matter under investigation.

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(g) Proving the Incendiary Origin of a Fire

Establishing the fact that the fire is incendiary is perhaps the most important single element of an arson case. For practical purposes, it means that certain facts must be established to show that a crime was committed. Generally speaking, every fire is presumed to be of accidental, natural or providential origin until the Crown can prove beyond a reasonable doubt, that the fire was of wilful and malicious origin. Anything found at the scene that might have been used to start or spread the fire will help prove this important ingredient and should be carefully noted and protected.

22. THE PROPER HANDLING OF EXHIBITS

From the instant an exhibit is discovered until it is received as evidence in the court and so marked, the line of possession must be proved to be continuous. If this line of possession is broken by a person through whose hands it passed, by his not being able to swear that it is the same exhibit, the exhibit will not, and definitely should not be accepted as evidence. An exhibit is anything which may be used to prove or disprove any point in question. When such exhibits are found, they should be guarded until the arrival of the investigator. If this is not possible for any reason, they should be photographed and handled in such a way that fingerprints will not be destroyed. If no photographer is available and it is imperative that the exhibit be moved (e.g. the fire is moving towards the exhibit), two people should be present before it is disturbed so that one witness can corroborate the evidence of the other in court. The exhibit must be marked for identification before being locked up or passed to the investigator. If the exhibit is a liquid that may have to be analyzed, it should be put in a spotlessly clean container that can be securely sealed. Any person handling the exhibit should make notes of the time and circumstances under which he found or handled it and the

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time and circumstances that he passed it on to another person. All such persons will have to appear as witnesses and notes made at the time of an occurrence can be used in the witness box to refresh your memory. Notes made from memory some time after the occurrence cannot be used, and it should be noted that it may be several months or even years before the case is finally concluded in the courts.

23. STAKEOUT

In cases where there is a series of incendiary fires in a particular area, with no apparent motive, it is usually necessary to ask fire fighters to assist in the stakeout. The stakeout is absolutely useless if any unauthorized persons are aware of it.

24. COURT APPEARANCES

It is always advisable to go over your notes before you testify in court or, if you have given a written statement to the investigating officers, go over the statement so that you can familiarize yourself with your evidence. Your appearance is very important and often influences the court and as you are called as a witness in an official capacity, always wear your uniform, offering a neat and professional appearance. When you give evidence, stand erect and always be scrupulously fair.

25. ARSON

The actual offence of Arson is found in Section 389 of the Criminal Code and it reads as follows:

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(1) Everyone who wilfully set fire to

- (a) a building or structure, whether completed or not,
- (b) a stack of vegetable produce or of mineral or vegetable fuel,
- (c) a mine,
- (d) a well of combustible substance,
- (e) a vessel or aircraft, whether completed or not,
- (f) timber or materials placed in a shipyard for building, repairing or fitting out a ship,
- (g) military or public stores or munitions of war,
- (h) a crop, whether standing or cut down, or
- (i) any wood, forest, or natural growth, or any lumber, timber, log, float, boom, dam or slide,

is guilty of an indictable offence and is liable to imprisonment for fourteen years.

(2) Every one who wilfully and for a fraudulent purpose sets fire to personal property not mentioned in Subsection (1) is guilty of an indictable offence and is liable to imprisonment for five years.

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FALSE FIRE ALARM

393 Every one who wilfully, without reasonable cause, by outcry, ringing bells, using a fire alarm, telephone or telegraph, or in any other manner, makes or circulates or causes to be made or circulated in alarm of fire is guilty of -

- (a) an indictable offence and is liable to imprisonment for two years, or
- (b) an offence punishable on summary conviction.

Although this Section is not usually used by fire investigators, it becomes invaluable to police and fire departments when they are plagued by juveniles constantly committing the offence.

26. PHYSICAL EVIDENCE IN AUTO FIRES

The fire scene: The typical auto fire scene is usually one which is located on a lonely traffic-free country road. In most cases the exact spot of the fire will be situated such that no houses are in sight from either direction. It has been noticed in past investigations of suspicious fires that heavy cover from woodland beside the road, is a popular requirement of the car fire setter. Further, the fire scene will probably be located between two points frequently travelled by the perpetrator. Of course, we have investigated fires which occurred in thickly populated areas or at the owner's home, however, the above location is by far the most popular. An abundance of physical evidence is always available at the fire scene as we will point out below.

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Footprints: Let me explain the importance of footprints you will find at some auto fire scenes. In a very high percentage of total auto fire reports, the owner will report his car as stolen and subsequently recovered burned. He will make a detailed report of theft to the insurance adjuster and also to the police. He will usually state that his car was taken from its normal parking place near his home or from some place downtown and that he has no idea who might have taken his car and burned it. A search of the fire scene resulting in the location of the owner's footprints at the scene would prove to be valuable physical evidence in a subsequent court action.

Tire Tracks: When approaching the fire scene always be careful not to drive too close to the burned car. This particular fire scene may show evidence of tire tracks from another car which was used to transport the perpetrator from the scene. The owner usually picks a spot some miles from his home to burn his vehicle. The finding and identifying of tire tracks from his associate's car, as in the case of footprints, constitutes good physical evidence.

Location of Container: Often times gasoline or kerosene which is to be used for the accelerant is purchased by the perpetrator and carried to the fire scene. In his excitement the burner will dispose of the container in the nearest cover. A search of the immediate area may disclose the location of this container, still containing some of the gas or kerosene and perhaps the burner's latent prints. Corroboration of the container can be established many times if the investigator will check nearby stations in an attempt to learn if the operator remembers selling the gas or kerosene in that particular container.

Unburned Matchsticks in Motor Compartment: It is uncanny how matchsticks will survive the roaring fire in the engine compartment. Look closely in the dustpans or other of the many nooks and crannies in the engine compartment. Both book matches and wooden matches have been found in these locations. This effort should be accomplished at the fire scene if possible, since the matchsticks may fall out as the car is being moved by the wrecker.

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Missing Wheel Lug Bolts: It is a common practice for the car burner to exchange tires on the car prior to the fire. When this is done, the owner is usually in a hurry and will invariably leave out one or two of the lug bolts or nuts. Check closely, at the crime scene, for sometimes it is necessary for the culprit to replace wheels on the car in order to tow it to the wrecking yard.

Unburned Tire Pads: By unburned tire pads we mean that portion of the tire which is situated between the rim and the ground which will not burn during the fire. There will always be a small amount of the tire left intact and through examination of this remaining portion it is possible to tell the condition of the tire and the type of tread. Many times the owner will tell the insurance adjuster that he had brand new tires on his car, thinking that his worn tires were completely destroyed during the fire.

Removal of Scented Soil From the Fire Scene: In his haste during the burning, the perpetrator may spill a certain amount of the accelerant on the ground or some of it will drip through the floorboard of the car. In any case, always check the ground under and around the vehicle. By digging down a few inches, depending on the texture of the soil, you may find the dirt to have a gasoline or kerosene odour. Place this dirt in an airtight container and it will prove valuable in your further pursuits of the investigation.

Location of Gas Tank Drain Plug: We have had cases where the drain plug in the bottom of the gas tank was removed, the gas drained on the ground, ignited, causing the car to burn. Always examine the drain plug. Check to see if it is missing. Check for fresh plier marks. Check the ground under and around the car in cases where the plug is missing. Many times great heat from the interior of the car will cause the drain plug to fall out completely with the threaded collar, however, this can easily be ascertained with close inspection.

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Missing Gas Tank Cap: When the gas tank cap is missing at the fire scene it no doubt will call for some explanation from the owner. Some owners might tell you that the cap blew off from an explosion on the interior of the vehicle. This can easily be disproved by explaining that the flanges on the filler neck are not bent outwards as they would be in the event of an explosion. A gas tank explosion in an auto fire is a rarity inasmuch as the oxygen and gasoline mixture must be exactly correct for the tank to explode. It is unusual to encounter an exploded tank fire.

Seat and Lazyback Springs - Loss of Temper: Check the seat springs in the burned vehicle. If all temper is gone and if the springs are sagged, incendiarism is indicated. This is also true of a sagged top on the vehicle, which indicates intense heat which may have been caused by the use of an accelerant. However, it should be kept in mind that today's foam upholstery also produces terrific heat.

Missing Vital Engine Accessories: Always check the engine for missing parts which would render the vehicle inoperable. You may find missing starters, generators, batteries and even carburetors. Check for loose bolts in the compression head and manifold. This may indicate that the owner had been attempting to repair the engine. Many times you will find these discrepancies, yet the owner has stated that he was driving the vehicle just prior to the fire.

Fuel System and Electrical System: You must pay particular attention to the fuel and electrical system of the burned vehicle, since these two parts of the vehicle are the fire causes in all, or mostly all, accidental fires. Check for tampered fuel lines from the carburetor to the fuel pump to the gas tank. Look at the connections of these fuel lines for evidence of fresh plier marks. Check the wiring system for shorted wires which are evidenced by beaded ends. A wire which has burned apart will have sharp ends. Check for fused voltage regulator or relay points. Remember with regard to the electrical system, you are attempting to disprove the existence of electrical short circuit.

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Finding of Ignition Key in Debris: Many times in cases of total auto fire losses, the owner will report his car stolen as we mentioned heretofore. When this happens he will more often than not tell the adjuster that he has the only set of keys to his car in his pocket. A search of the debris in the front floor board might net you another set of ignition keys which had fallen when the soft metal keyway melted as the result of the fire. The owner is usually under the impression that if he tells the adjuster that he left his keys in his car prior to the alleged theft, the insurance company will not be liable.

Finding of Remains of Contents Claimed in Car by Owner: In an attempt to gain a larger insurance settlement, many times the owner will claim that he had various items in his car at the time of the fire. Some common things claimed are clothing, fishing equipment, tools, etc. A close search of the debris will indicate whether or not these claims are true. Look for zippers, metal buttons or any other parts of these articles which would not be destroyed in the fire.

Identification of the Automobile: Always make certain that the burned vehicle is correctly identified through the motor or serial number and that this number is identical to the number on the insurance policy. It could prove embarrassing for you in court in the event you were unable to identify your corpus delecti.

27. Definitions:

Accelerant -

Material; usually a flammable liquid that is used to initiate or increase the spread of a fire.

Alligatoring -

Large deep shiny charring which indicate extremely rapid fire spread; perhaps the use of flammable liquid.

Area of Origin -

The localized area where a fire originated.

Arson -

The crime of purposely setting fire to another's building or property, or to one's own, as to collect insurance.

Burn Pattern -

Apparent and obvious design of burned material and the burning path of travel from a point of fire origin.

Fire -

Rapid oxidation, usually with the evolution of heat and light; heat oxygen and interaction of all three.

Ignition Source -

Mechanism employed to initiate combustion.

Incendiarism -

Deliberate setting of a fire or fires by a human being.

Incendiary Device -

Contrivance designed and used to start a fire.

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Spalling -

Explosive pitting or chipping destruction of a surface, usually concrete, from intense heat buildup commonly caused by the activation of an accelerant.

Splash Pattern -

Characteristic pattern left on a wall by an accelerant splashed there, usually in the shape of an inverted "V".

Trailer -

Combustible material, such as rolled rags, blankets, and newspapers, or flammable liquid, used to spread fire from one point or area to other points or areas, often used in conjunction with an incendiary device.

NOTE: "FOR ADDITIONAL INFORMATION, REFER TO I.F.S.T.A. MANUAL."

(1986)

CHAPTER 18

COMMUNICATIONS

SCOPE OF COMMUNICATIONS

1. INTRODUCTION

For the purposes of this text, the term 'Communications' will address a variety of issues ranging from the traditional concept of radio telephony to the use of telephone communications devices.

Object of Radio Communications

To enable fire suppression companies to effectively communicate with the Control station and with other companies sharing the fireground. The reliability of such a system depends largely on the co-operative effort of those persons utilizing the system to respect the guidelines established.

2. COURTESY IN COMMUNICATIONS

MONITOR the frequency before beginning any transmission. Transmission of any message prior to the completion of an in-progress transmission will only cause distortion and failure of the Communications Operators to recognize either message.

SPEAK CLEARLY and concisely across the face of the microphone when transmitting messages. In the case of 'Noise Cancelling Microphones', speak clearly, concisely and directly into the face of the microphone with the microphone just in contact with the upper lip.

DO NOT transmit information that is too lengthy and/or detailed without breaking it into smaller components; or it may be confused and further endanger the situation.

BEFORE conducting 'Vehicle to Vehicle' communications, (other than units participating in alarms), channel clearance from CONTROL will be obtained so that the 'Value' of 'Control' is maintained.

3. COMMUNICATIONS PROCEDURE CODE (10 CODE)

- 10-1 Receiving poorly.
- 10-2 Receiving loud and clear.
- 10-3 Stop transmitting.
- 10-4 Message received -- Acknowledgement.
- 10-5 Relay message.
- 10-6 How do you receive (radio test).
- 10-7 Not available or Out of Service
- 10-8 Available for service.
- 10-9 Repeat message.
- 10-12 At the alarm scene.
- 10-14 Acknowledgement to Transmit.
- 10-16 Vehicle breakdown.
- 10-17 Request for OFM Investigator or CID.
- 10-19 Return to quarters or resume previous detail.
- 10-20 What is your location
- 10-21 Call by telephone.
- 10-33 Request Police assistance (sensitive situations only).
- 10-45 Denotes dead person.
- 10-65 Denotes alive person.

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4. PHONETIC ALPHABET

There are numerous phonetic alphabets, and there is nothing to prohibit the radio operator from developing his/her own (providing it will be understood by other operators that he/she is communicating with).

This phonetic alphabet was developed by the International Aviation Organization (ICAO), and has been adopted by most other radio services employing speech communications.

A	-----	ALPHA
B	-----	BRAVO
C	-----	CHARLIE
D	-----	DELTA
E	-----	ECHO
F	-----	FOXTROT
G	-----	GOLF
H	-----	HOTEL
I	-----	INDIA
J	-----	JULIETTE
K	-----	KILO
L	-----	LIMA
M	-----	MIKE
N	-----	NOVEMBER
O	-----	OSCAR
P	-----	PAPA
Q	-----	QUEBEC
R	-----	ROMEO
S	-----	SIERRA
T	-----	TANGO
U	-----	UNIFORM
V	-----	VICTOR
W	-----	WHISKEY
X	-----	X-RAY
Y	-----	YANKEE
Z	-----	ZULU

(1986)

5. MOBILE RADIO EQUIPMENT

There are three types of mobile two-way radio equipment being used by the Hamilton Fire Department:

Mobile Radio;

Portable Radio;

Mobile Repeaters;

All personnel may at any time be required to operate any or all of the devices that will be discussed, therefore a good working knowledge must be obtained early.

Mobile Radios

Types: Trunk mount	MOCOM 70
	MITREK
Unitized	MCX 100

A trunk mount radio is a radio that utilizes a remote control radio head to operate the transmit and receive functions as opposed to a unitized radio that completely mounts under or on the dash of a vehicle. The trunk mount radio offers the maximum flexibility for the Fire Department, in that it allows a variety of options to be connected easily.

(1986)

CONTROL HEADS

STANDARD MOCOM CONTROL HEAD

The operator controls include: Volume/Power; Squelch; Frequency Selector (CH 1 - CH 4); Power indicator (green); and Transmit indicator (red).

MOCOM OR MITREK - ENHANCED CONTROL HEAD - SYSTEMS 90

The operator controls include: Volume; Squelch; Frequency Buttons (F1 - F4); Power (orange button); Transmit Indicator (red). Indication that power is applied to the radio set is portrayed by the backlighting of the control head. The selected frequency is more easily identified with the bright lighted window over the frequency button.

A special feature incorporated by this control head causes the frequency to revert to a preassigned channel if all of the buttons are inadvertently released (F3).

OPTIONS:	Extended Control	Pumps, Aerial, RU's
	Electronic Siren	Motorola Integrated
	Electronic Siren	Federal Standalone
	Channel Scan	Cars 1, 2, & 3.

(1986)

BASIC CONTROL HEAD OPERATION

Controls: ON/OFF

MOCOM - Rotate the volume control clockwise to turn on.

SYSTEM 90 - Depress the desired channel button to turn on. Depress the Orange 'Off' button to turn off.

VOLUME

Increases or decreases the received audio level.

SQUELCH

MOCOM - Rotate counter-clockwise -

SYSTEM 90 - Rotate to the left - to the point when the squelch noise begins and then adjust in the opposite direction just until the noise stops. This is the point of maximum receiver sensitivity.

CHANNEL

MOCOM - Rotate the frequency selector to the desired channel position, normally CH-3.

SYSTEM 90 - Depress the desired channel button. The orange indicator lamp will glow much brighter than the others.

TRANSMIT

MOCOM - When the PTT switch on the microphone is depressed the (Red) jewel indicator glows.

SYSTEM 90 - The red indicator over the On/Off button glows.

NOTE:

You will note that Systems 90 control heads are backlighted for easier night operation.

(1986)

EXTENDED CONTROL

This is a device that allows the operator of a Pump, Aerial or Rescue unit to transfer operation of the interior radio control head to the exterior of the vehicle. The transfer includes the Transmit, Receive, Frequency selection, Speaker volume and Handset Volume controls. The exterior control head is weatherproof and utilizes a handset rather than a palm type microphone which is found in the cab.

When control has been transferred the 'REAR' lamp on the transfer control head in the cab will be illuminated as well as the green pilot lamp on the exterior control head.

OPERATION:

To transfer operation of the mobile radio to the exterior,

1. Rotate the transfer control knob (MOCOM) to the 'REAR' position.

Depress the 'REAR' transfer button (SYSTEM 90).

2. To transmit from the 'Rear' control head depress the 'Push-To-Talk' button on the underside of the handset and speak into the microphone element on the lower portion of the handset. The 'Red' indicator will illuminate for each transmission.
3. To listen the Operator may receive messages from either the receiver element of the handset or the exterior speaker.
4. There are independent volume controls on the exterior control head for volume adjustment of the handset and exterior speakers.

(1986)

CHANNEL SCAN

OPERATION:

This option is only located in: Car 1; Car 2; and Car 3.

It is designed to allow the vehicle operator to monitor radio traffic on each of the equipped frequencies simultaneously or one selected channel of the operators choice only. It further provides priority monitoring of a preselected channel during the SCAN mode. This option is only used with the Systems 90 control heads.

- INITIALIZE - Adjust the mobile 'Squelch' prior to selecting the 'Scan' function. When the squelch is set depress the orange 'SCAN' button.
- PRIORITY - Depress the 'P1 through P4' button desired for the channel that you wish priority monitoring of. The 'P' buttons correspond with the 'F' channel selector buttons.
- RECEIVE - The active channel will be indicated by illuminating the corresponding 'P' indicator more brightly than the others.
- TRANSMIT - The radio will transmit only on the channel that has been selected on the control module, F1 through F4.
- SCAN OFF - If the scan is not selected, the radio will operate normally as if the scan option was not installed. The backlighting on the SCAN module will be extinguished.

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PORTABLE RADIOS

The portable radio is an extension of the Fire Department Officer's ability to communicate with his apparatus unit from the fire scene, with Control, or with a more senior officer at the scene. Although we have assumed through use, that the portable radio should at all times be able to communicate across any distance or through any medium, the unit has certain limitations and certain cautions must be exercised with its use.

<u>TYPES:</u>	HT220	Slimline	2 watts	2 Channel
	HT220	Omni	5 watts	2 Channel
	HT220	Omni	5 watts	4 Channel
	MT500	Omni	5 watts	4 Channel
	HT440	Omni	5 watts	4 Channel
	HT 90	Omni	5 watts	2 Channel

(1986)

Portable Radio Channelization

Due to the implementation of portable radios over several years there have been several models issued. The following table will clarify the manner in which channels appear on Fire Department portables.

2 Channel Fire Suppression	F1 - Region F2 - Hamilton
2 Channel Training Division	F1 - SFRC Exercises F2 - Hamilton
2 Channel Fire Prevention	F1 - Alarm Testing F2 - Hamilton
4 Channel Non Repeater	F1 - Region F2 - OFM F3 - Hamilton F4 - Spare
4 Channel MX350 type for Mobile Repeater	F1 - Region F2 - OFM F3 - Hamilton F4 - Repeater

NOTE: For an explanation of 'Repeater' see - PAC RT

(1986)

6. ELECTRONIC SIRENS

The Hamilton Fire Department exclusively uses electronic sirens on its emergency response apparatus. Due to changing technology, a variety of model types will be found including differentiation in power levels.

<u>TYPES</u>	FEDERAL	PA-15	58 watts
		PA-20	58 watts
		PA-200	100 watts
	MOTOROLA	Hi/Lo	120 watts

OUTPUT - The main siren component, located in the vehicle is a multi-function tone generator and amplifier. The output from this device is connected to a high power speaker generally found in the base of the rotating beacon light or in a speaker horn mounted on the roof of the vehicle cab.

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CONTROLS - FEDERAL

GAIN - Contains the On/Off switch and controls the power output level for the PA function only. The position of this control, once turned ON is not important during the siren mode.

The various functions are controlled by rotating the center switch to the desired position.

MANUAL - By depressing the 'Siren' button or a remotely located 'Siren' button the siren tone will rise until the button is released at which time it will fall to an OFF state until depressed again.

WAIL - The tone automatically rises and falls at moderate speed.

YELP - Functions the same as 'Wail' only at a greater speed.

HI/LO - The siren unit alternately switches between the highest and lowest tones.

RADIO - When this option is wired, the radio audio may be played through the external siren speaker. It was a popular option prior to the implementation of portable radios.

PA - allows the user to convert the siren to a public address amplifier by speaking into the siren microphone. The amplified audio is directed to the external siren speaker. The audio level is controlled by the 'Gain' control. If feedback is experienced, reduce the gain level.

PILOT LIGHT - The control panel of the siren control unit is illuminated whenever the unit is turned On only.

(1986)

CONTROLS - MOTOROLA

ON/OFF - Depress the leftmost orange button to turn Off. To turn on depress any function button except 'PA'.

MANUAL - This function requires the installation of a remote SIREN button. When the button is depressed, the tone rises to a high level until released. When released, the tone will fall to the quiet state.

WAIL - The tone rises and falls moderately. If the SIREN button is depressed during this mode the function will automatically switch to the 'Yelp' mode until the button is released. This is useful when approaching intersections.

YELP - The tone rises and falls quickly. DO NOT depress the SIREN button during this mode.

HI/LO - The tone alternately switches between the lowest and highest tones. This tone was associated with OHSC ambulances in the Province of Ontario until recently.

RADIO - In Motorola Siren/Radio configurations, the radio audio is automatically available to be switched to the external siren speaker by depressing the 'Radio' function button.

PA - In Motorola Siren/Radio configurations, the radio microphone serves both the radio and public address functions.

CAUTION - When the PA function button is depressed, the mobile radio push-to-talk (PTT) circuit is disabled.

NOTE - When the PA function button is depressed, the siren tones are interrupted whenever the microphone PTT button is depressed. The selected siren function will continue immediately on the release of the PTT button.

VOLUME - Controls the amount of microphone gain during the PA function.

The Siren controls are backlighted whenever the siren or auxiliary functions are selected.

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7. STATION COMMUNICATIONS EQUIPMENT

EQUIPMENT - Remote Console (Watchbooth)
 Base Station
 Public Address Amplifier

REMOTE CONSOLE

The Motorola ST1608 FFP Remote Console is the core of the Station Communications System. It processes and receives all alarm information and provides the station with a local transmitter.

Normally, an audio message that is received by the station enters the console by leased telephone line and is passed directly to the public address amplifier and the attached speaker system.

OPTIONS

MICROPHONE - The microphone provides the user with the ability to make announcements via the station's public address system, or transmit messages via the base station radio.

TRANSMIT - Depress the right side of the microphone base to cause the base station to transmit.

MONITOR - A non functioning control at this time.

INTERCOM - To use the public address system intercom, the Intercom control is depressed on the console and the user speaks into the microphone element. DO NOT DEPRESS Transmit or Monitor.

(1986)

CONTROLS

POWER - The power switch is a two position rotating control, rotate clockwise to energize. The green pilot indicator will illuminate. Rotate counter-clockwise to turn off.

VOLUME - Located directly below the Power switch. Rotate clockwise to adjust the volume to a comfortable level. The level of the volume control has no effect on the amount of audio emitting from the public address amplifier.

POWER INDICATOR - Located above the Volume control, illuminates whenever the Power control is in the ON mode. If the console is connected to a standby battery supply this indicator will flash as long as the commercial power is removed.

TRANSMIT INDICATOR - a red indicator, located next to the power indicator and will illuminate whenever the transmit bar of the microphone has been depressed.

ACKNOWLEDGE (ACK) - Depress to acknowledge confirmation of receiving an alarm, test or special announcement. This action causes a change in status on the Communications console for the associated station.

DAY/NIGHT - When depressed the audio to the public address amplifier is temporarily interrupted. This is a non locking device. When depressed the indicator changes from Day to Night. Regardless of which mode this control is in, the audio from the console speaker is not affected.

INTERCOM - When depressed the microphone audio is routed to the public address amplifier. This provides each station with an internal public address intercom.

CAUTION - Whenever this control is depressed the audio line from Communications is interrupted which may cause failure to receive alarms.

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RESET - Whenever the base station has been activated by paging tones from the Communications Center the red indicator immediately adjacent will illuminate and all received audio at the base station will be directed to the public address amplifier.

To reset this condition depress the RESET button.

Whenever the RESET indicator is illuminated a parallel indicator will be illuminated on the base station. There is also a RESET button located on the front panel of the base station.

CAUTION - Whenever the RESET indicator is illuminated the audio line from Communications is interrupted which may cause failure to receive alarms.

(1986)

CHAPTER 19

PRIVATE FIRE PROTECTION AND DETECTION

AUTOMATIC SPRINKLER SYSTEMS

1. INTRODUCTION

The life safety of building occupants is enhanced by the presence of a sprinkler system because it discharges water directly on the fire while it is relatively small. Since the fire is extinguished or controlled in an early stage, the combustion products are limited.

The basic sprinkler system contains a suitable water supply, an integrated system of piping, sprinkler heads, controlling valve and a device for actuating an alarm when the system is in operation. The system is actually activated by heat from a fire and discharges water over the fire area.

TYPES OF SPRINKLER SYSTEMS

The five major classifications are:

Wet-Pipe System - These systems employ automatic sprinklers attached to a piping system containing water under pressure at all times. When the fire occurs, individual sprinklers are actuated by the heat and water flows through the sprinkler immediately.

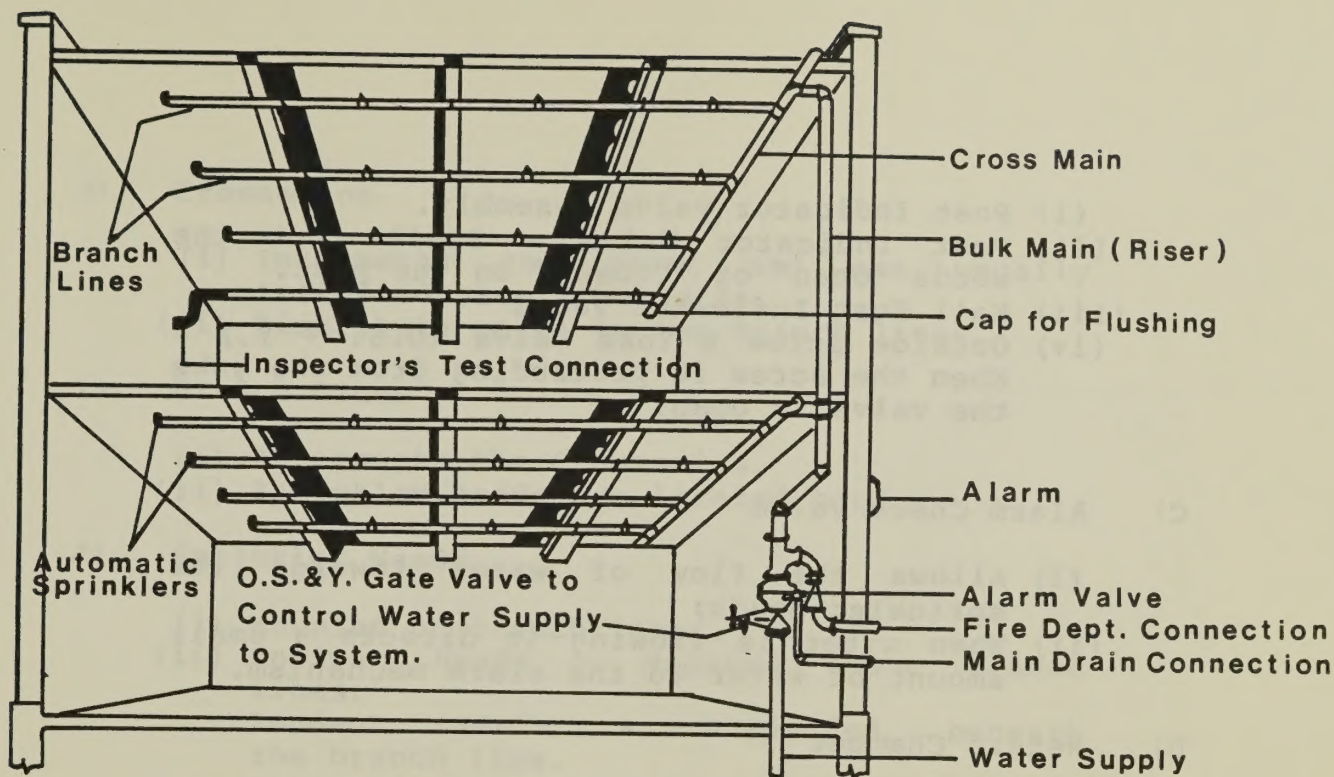
Dry-Pipe System - Regular Dry-Pipe systems have automatic sprinklers attached to piping which contains air under pressure. When a fire occurs, individual sprinklers are actuated. The pressure in the system is reduced thus opening the "Dry Pipe Valve" allowing water to flow through any opened sprinklers.

Pre-Action System - Pre-Action systems are Dry-Pipe systems in which air in the piping may or may not be under pressure. When a fire occurs, a supplementary fire detection device in the protected area is activated thus opening the electrically controlled "Alarm Valve" which permits the water to flow through the piping and be discharged through any open sprinklers which may have been opened by the heat of the fire.

Deluge System - These systems are similar to the Pre-Action systems except that all the sprinklers are open at all times. When heat from a fire activates the supplementary fire detection device, water flows through the piping system and is discharged from all the open sprinklers thus "deluging" the entire protected areas.

Combined Dry-Pipe And Pre-Action System - These include both the essential features of both types of systems. The piping system contains air under pressure. A supplementary heat detecting system opens the "Alarm Valve" and an air exhauster at the end of the feed main. The system piping then fills with water and operates as a wet pipe sprinkler system. If the supplementary heat detecting system should fail then the system will operate as a regular Dry-Pipe system.

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**SPRINKLER SYSTEM PIPING
LAYOUT**

Typical piping schematic of an automatic sprinkler system, showing important parts.

Wet Pipe System Components

- A) Water supply from city water mains.
- B) Main Water Control Valve - located at the head end of the sprinkler system. There are four (4) basic water control valves.

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- (i) Post Indicator Valve Assembly.
- (ii) Post Indicator Valve - Spells out the words "Open" or "Closed" on the post.
- (iii) Wall Post Indicator Valve
- (iv) Outside Screw & Yoke Valve (O.S. + Y.) - When the screw is protruding from the yoke the valve is open.

C) Alarm Check Valve

- (i) Allows the flow of water towards the sprinkler heads;
- (ii) When water is flowing it directs a small amount of water to the alarm mechanism.

D) Retard Chamber

- (i) Located adjacent to the alarm check valve.
- (ii) Purpose is to prevent false alarms due to the fluctuation of water pressure.

E) Water Motor

- (i) Located next to the Retard Chamber;
- (ii) Purpose is to power a paddle which sounds a water gong located outside of the building. It may also activate a pressure switch which activates an alarm.

F) Fire Department Inlet From Fire Department Connection

- (i) Check valve to keep water from draining back out of the system;
- (ii) Inlet is located above the Control Valve which allows water to the system even if the sprinkler valves are closed or are malfunctioning.

G) Riser

- (i) High capacity water main which carries water from the control area.

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H) Crossmains

- (i) Intersects the riser and are usually installed along the walls.
- (ii) Distribute water to the branch lines.

I) Branch Lines

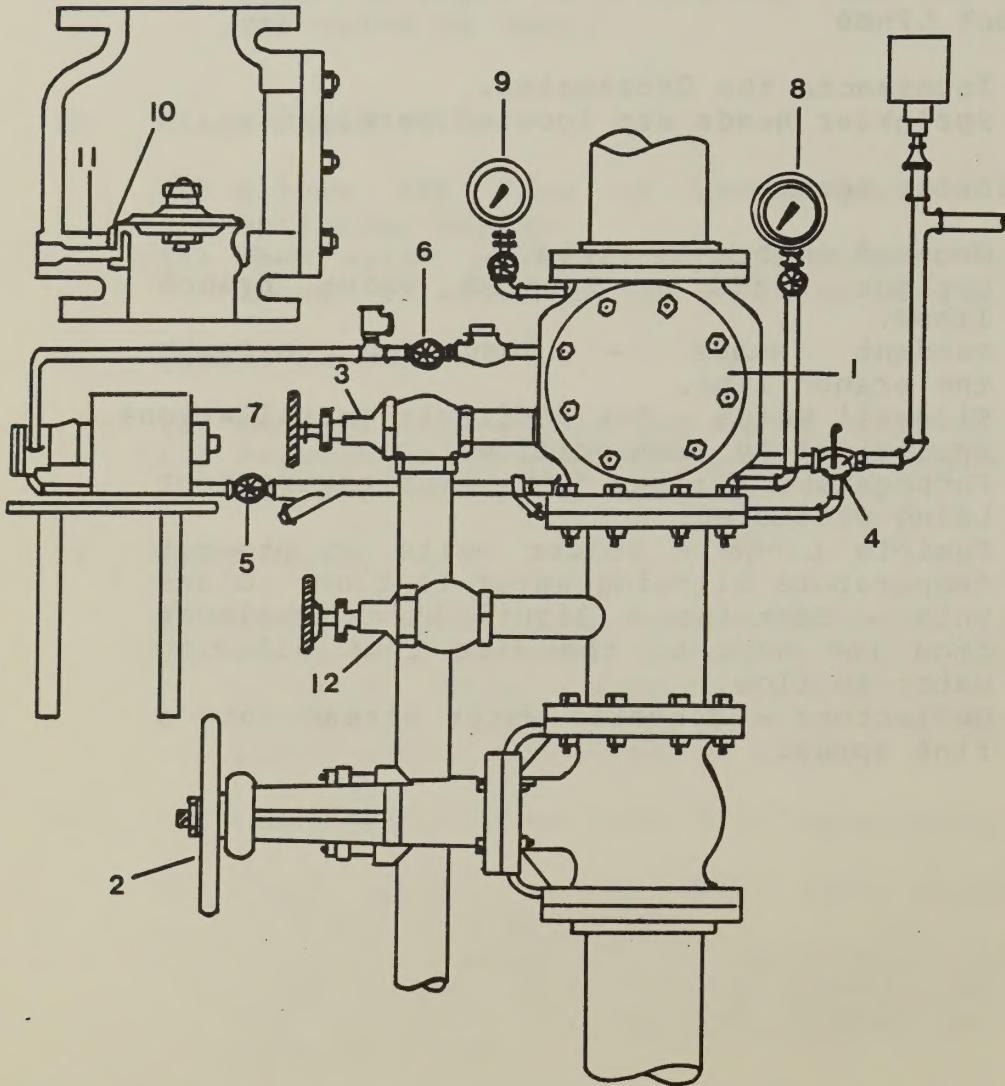
- (i) Intersects the Crossmains.
- (ii) Sprinkler heads are located here.

J) Sprinkler Heads

- (i) Mounted on branch lines.
- (ii) Upright Heads - Mounted above branch lines.
Pendant Heads - Suspended beneath the branch line.
Sidewall Heads - For difficult installations.
- (iii) Approximately 12mm orifice.
- (iv) Temperature ratings vary with environment being protected.
- (v) Fusible Links - Solder melts at pre-set temperature allowing water to flow. Glass Bulb - Contains a liquid which explodes from the heat of the fire thus allowing water to flow.
- (vi) Deflectors - Converts water stream into a fine spray.

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WET PIPE SYSTEM



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Explanation of Wet Pipe System

DESCRIPTION

1. Alarm check valve.
2. Main control valve.
3. Main drain valve.
4. Three way alarm test valve.
5. Pump suction.
6. Pump discharge.
7. Excess pressure pump.
8. Gauge, City water pressure.
9. Gauge, excess pressure.
10. Clapper, held in place by excess pressure to prevent false alarm.
11. Orifice to admit pressure to alarm switch and water motor when sprinklers operate.
12. Flow test valve.

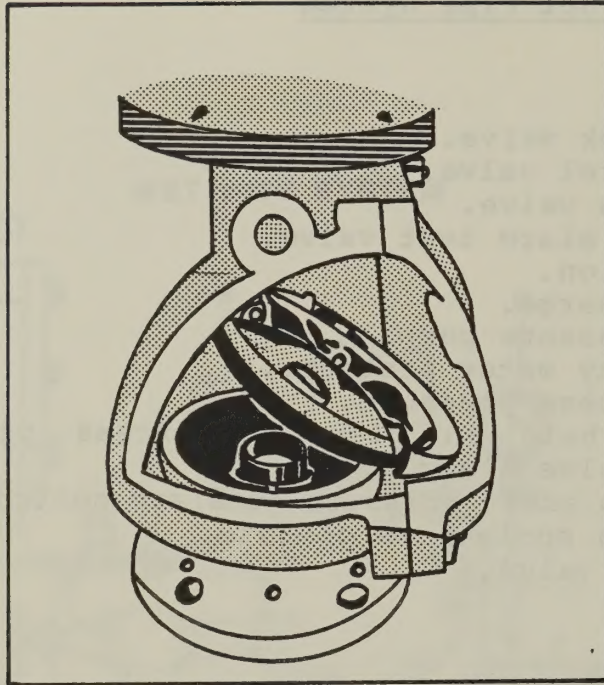
DRY PIPE SYSTEM

A Dry Pipe system is one where air under pressure replaces water in the sprinkler piping above the dry pipe valve. A dry pipe valve is a device that keeps water out of the sprinkler piping until a fire actuates a head or heads. Dry systems are used in buildings or areas where insufficient heat is maintained to keep water from freezing (i.e. - underground parking garages).

HOW A DRY SYSTEM OPERATES

When a sprinkler head fuses, permitting the air pressure to escape, the dry pipe valve automatically opens to permit water to replace the air pressure in the lines. Dry pipe valves are designed so that a small amount of air pressure above the dry pipe valve in the sprinkler piping will hold back a much greater water pressure on the water supply side of the dry pipe valve. This valve is commonly known as the Differential Dry Pipe Valve. The upper air seat is considerably larger than the lower, or water seat with a surface ratio that is normally six to one. The difference in surface area of these two seats determines the difference between water pressure and air pressure that is necessary to "Balance" the valve. Normal air pressure is usually 210 - 280 kPa.

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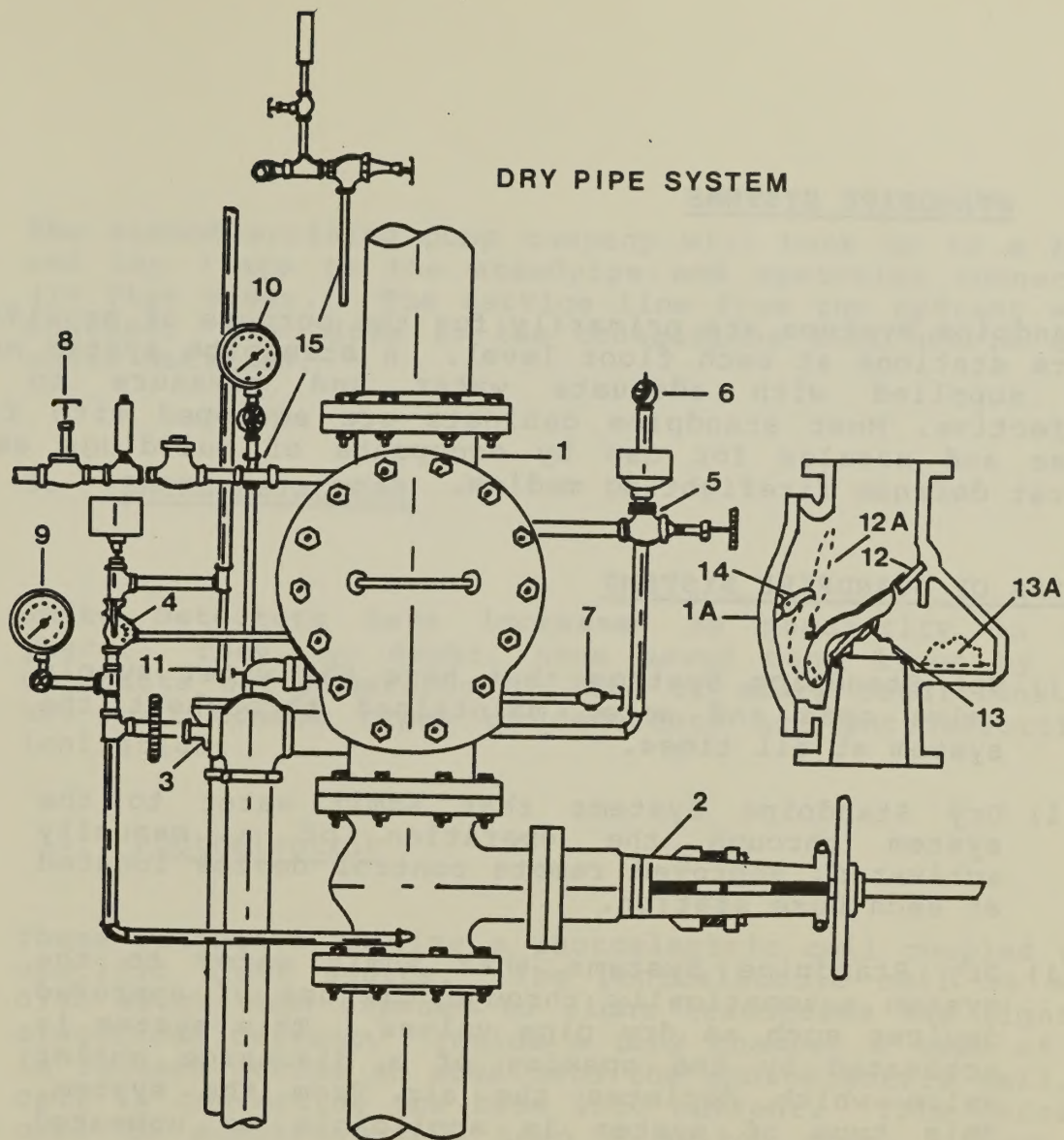


A differential dry-pipe valve obtains its name from the small water seat in the center of the valve as compared to the large air seat above it.

ACCELERATORS AND EXHAUSTERS

In a large dry system several minutes could be lost while the air is being expelled from the system. Systems that have a capacity of over 2200 litres normally require a quick-opening device. There are two types of quick-opening devices: Accelerators and exhausters. The accelerator unbalances the differential in the dry pipe valve, causing it to trip more quickly, whereas the exhauster quickly expels the air from the system.

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Explanation of Dry Pipe System

1. Dry pipe valve (1 A Cover plate)
2. Main control valve
3. Main drain valve
4. Three way alarm test valve
5. Priming Water control valve
6. Priming water supply
7. Body drain
8. Air supply valve
9. Water gauge
10. Air gauge
11. Drip check valve
12. Air seat (12 A Clapper)
13. Water seat (13 A Clapper)
14. Latch
15. Test valve to indicate priming water level

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2. STANDPIPE SYSTEMS

Standpipe systems are primarily for the purpose of providing fire stations at each floor level. A standpipe system must be supplied with adequate water and pressure to be effective. Most standpipe cabinets are equipped with fire hose and nozzles for use by occupants of buildings as a first defense firefighting medium.

TYPES OF STANDPIPE SYSTEMS

- i) Wet Standpipe Systems that have the water supply valve open and water maintained throughout the system at all times.
- ii) Dry Standpipe Systems that admit water to the system through the operation of a manually activated, approved remote control device located at each hose station.
- iii) Dry Standpipe Systems that admit water to the system automatically through the use of approved devices such as dry pipe valves. This system is activated by the opening of a discharge outlet valve which depletes the air from the system. This type of system is applicable to unheated structures.
- iv) Dry Standpipe Systems that have no permanent water supply and must be charged by the Fire Department.

FIRE DEPARTMENT OPERATIONS WITH STANDPIPES

It is the policy of the Hamilton Fire Department when responding to any apparent fire call to a building equipped with a standpipe and/or sprinkler system, the first arriving pump company enters the building. All men will don S.C.B.A. They will also carry with them the highrise pack, forcible entry tools, hand torch, inhalator and proceed to the floor below the fire. They then proceed to the fire floor and hook up to the standpipe system.

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The second arriving pump company will hook up to a hydrant and lay lines to the standpipe and sprinkler connections. (In That Order.) The service line from the hydrant will be charged. The lines to the connections will not be charged until notified.

3. SMOKE DETECTORS

Smoke Detectors have increased in popularity in recent years. They, no doubt, have saved many lives by giving occupants early warning of fire or smoke conditions. The two most common types of detectors are photoelectric and ionization.

(i) Photoelectric

These detectors utilize a photoelectric cell coupled with a specific light source. The photoelectric cell is a flat disc which when exposed to light transforms the light into electrical current. Inside a tiny chamber a beam of light is focused across an area onto the photoelectric cell. The cell is converting the beam into current. This current is used to electronically keep a switch open. When smoke enters this area, the path of the beam is blocked. The current therefore ceases to be produced and the switch falls closed, initiating an alarm signal.

(ii) Ionization

During a fire the molecules belonging to the products of combustion have an electron imbalance and will tend to rob electrons from other molecules. The ionization type detector utilizes this for operation.

The detector has a semi-open sensing chamber to sample the room air. A small amount of radioactive material is placed just inside the opening of the chamber. This radioactive material ionizes the air particles as they enter. Inside the chamber are two electrical plates, one positively

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charged and the other negatively charged. The action of the air particles ionized by the radioactive material is to free an electron, which travels to the positive plate and causes a small current to flow between the charged plates. When ionized products of combustion enter the chamber they pick up the free electrons caused by the radioactive ionization. The current flowing across the plates ceases thereby initiating an alarm signal.

4. HEAT DETECTORS

Basically there are three types of heat detectors. They are:

- (i) Fixed Temperature
- (ii) Rate of Rise
- (iii) Combined Principal

(i) FIXED TEMPERATURE PRINCIPLE

Thermostats are the most widely used fixed temperature heat detector in signaling systems. The common form of thermostat is the bimetal type which utilizes the different coefficients of expansion of two metals under heat to cause a movement resulting in closing of electrical contacts.

There are various types of thermostats.

1. Bimetallic Strip Thermostats.
2. Snap Action Disc Thermostats
3. Thermostatic Cable.

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RATE OF RISE PRINCIPLE

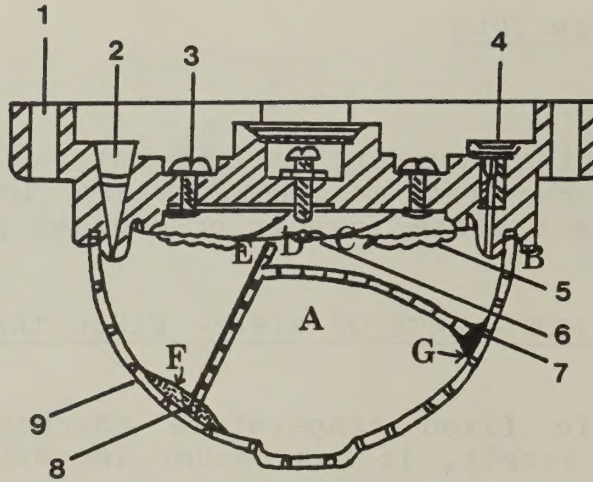
Fire detectors that operate on the rate of rise principle function when the rate of temperature increase and the detector exceeds a stated number of degrees per minute.

COMBINED PRINCIPLE - RATE OF RISE - FIXED TEMPERATURE

While bimetallic fixed temperature thermostat finds good application by itself, it has become increasingly common to use it in combination with the rate of rise detection principle. Rate of rise thermostats were developed to take full advantage of the capability of the rate of rise feature to sense and respond rapidly to a fast fire and the fixed temperature operating limit to take care of the situation where the growth of the fire was slow. If the growth of the fire was very slow the rate of rise capability might never come into play. The form which the rate of rise takes is a vented air chamber which leads up into a flexible diaphragm carrying electrical contacts.

Heat on the outside of the chamber causes air in the chamber to expand. When the expansion exceeds the capacity of the vent to relieve pressure, the diaphragm is flexed to close the electrical contact it controls. Slow changes in the ambient-temperature near the chamber allow it to "Breathe" through its vent, and the diaphragm is not moved sufficiently to an alarm. Detectors of this type have two ratings. One the speed of operation and the other the temperature at which the unit operates. Heat responsive devices are also used to activate alarm systems.

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COMBINATION RATE OF RISE AND FIXED TEMPERATURE

1. Mounting screw holes
2. Hermetically sealed vent
3. Wiring terminal screws
4. Metered air escape vent
5. Rate-of-rise actuating diaphragm
6. Rate-of-rise electrode
7. Fixed temperature contact spring
8. Heat-soluble fixed temperature element
9. Hermetically sealed air chamber. Added safety feature. Drainage holes prevent moisture-incurred short circuit hazard.

A spot-type combination rate-of-rise fixed temperature device. The air in Chamber "A" expands more rapidly, than it can escape from Vent "B". This causes pressure to close electrical contacts "D" between diaphragm "C" and insulating screw "E". Fixed temperature operation occurs when fusible alloy "F" melts releasing spring "G" which depresses the diaphragm closing the contact points.

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5. ALARM SYSTEMS

Over the last number of years alarm systems have become highly technical and in some cases quite complex. There are many different types and designs on the market today.

In addition to their primary function of detecting a dangerous situation and alerting the occupants, many alarm systems can perform secondary functions such as:

- Shutting down or reversing ventilation systems.
- Closing smoke or fire rated doors and dampers.
- Pressurizing stairwells for evacuation.
- Overriding control of elevators to prevent stops on fire floors.
- Returning elevators to Ground floor for Fire Department to use.
- Notifying Public Fire Department (or Supervisory Company) of an emergency condition.

For simplicity, only the BASIC ALARM SYSTEM will be covered.

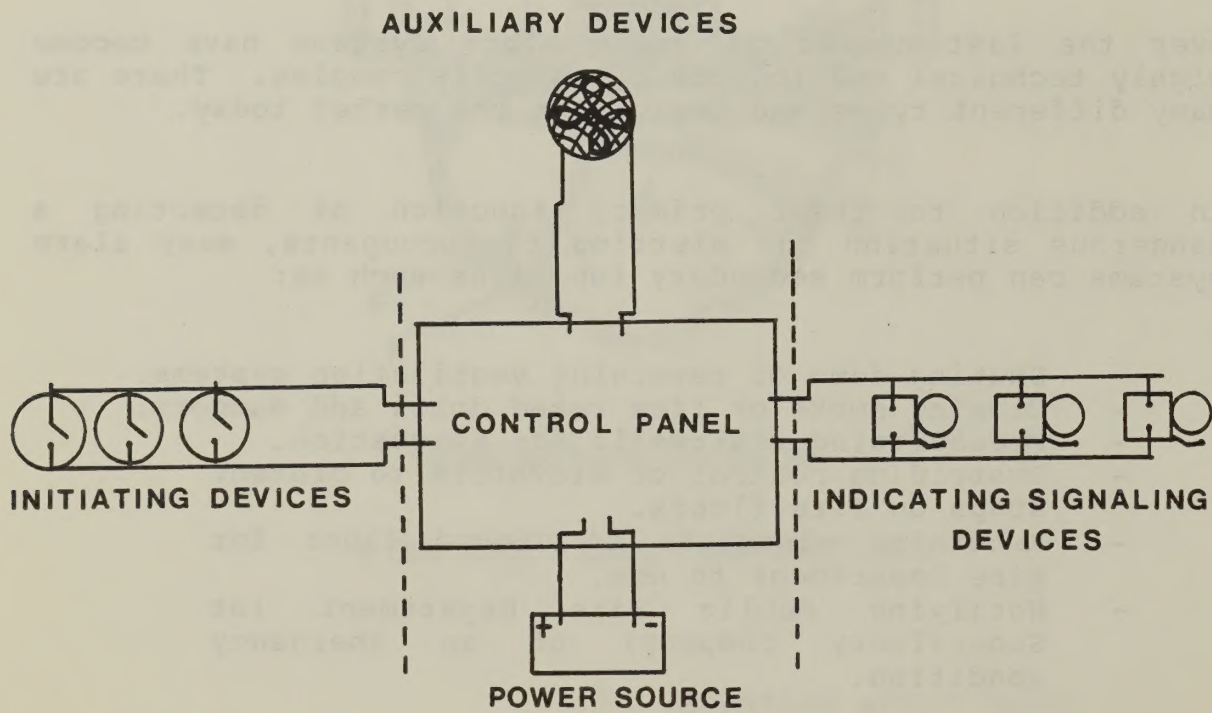
The primary purpose of a local alarm system is to alert the occupants and insure their life safety. The secondary purpose is property conservation.

The basic components of an alarm system are:

- The Control Panel
- Alarm Initiating Devices
- Signalling Devices
- Power Sources
- Auxiliary Devices

(1986)

The basic components of all alarm systems are the same. The elaborateness or the simplicity depends on the needs of the area to be protected.



CONTROL PANEL

Is the central nervous system of the alarm system. All components of the system are connected to the Control Panel and are controlled from the panel. Basic systems have the capability to receive a detection signal and then sounding an alarm either throughout the building or to predetermined areas.

(1986)

ALARM INITIATING DEVICES

The alarm initiating devices are the nerve endings of the system. It is through these devices that the alarm signal is originated. Common examples of these devices would be a smoke or heat detector manual pull box or a sprinkler head. When these devices detect a fire or smoke problem they transmit a signal to the control panel. The control panel then activates the signalling device.

SIGNALING DEVICES

These components convert the alarm initiating devices' signal into a signal that will alert the occupants. The most common type of a signalling device is the alarm bell. Others would include buzzers, horns, or electronic tones. The alarm signal can be non-coded, zone non-coded, master coded or zone coded.

Non Coded is the simplest type. Every alarm initiating device will sound an identical alarm signal. In other words the panel has no way to determine which alarm initiating device (or the area) sent the signal.

A Zone Non Coded system will be able to determine which zone the alarm signal originated. It will however produce only one alarm signal. The main advantage of this system is that it allows emergency personnel to determine which area or "zone" the alarm initiated.

Master Coded systems generate a code through the signalling devices. In other words it is a coded non-zoned system. Having this capability allows the bells to ring in a certain order or sequence. This allows personnel to determine the severity of the alarm. It may be set up in such a manner where the bells will ring intermittently to warn of a possible problem. After a certain length of time the bells will ring continuously thereby alerting occupants to evacuate. Another advantage of this system is that it allows the bells to be used for other purposes. (i.e. schools). The same bells could be used for class changes as it does for fire alarms. The fire alarm ring would have a distinct ring to it.

(1986)

Zone Coded systems as its name implies allows for the signalling devices to sound in a "coded" or distinct manner as well as being able to determine where the alarm signal originated.

Annunciator Panel

This panel is usually found in the lobby of a building or within close proximity of the main entrance. The main panel (usually in basements or electrical rooms) is where the system is re-set or silenced. The annunciator panel is simply an extension of the main panel and this is where it will indicate the whereabouts of the alarm.

The Annunciator Panel will be broken down into different zones. A zone could be an area or it could also be a function. An example of a zone could be "First Floor", "Penthouse", "Sprinkler Valve" or "Heat Detector".

There is also a trouble light on this panel which will indicate a fault in the system.

Hand held microphone at the panel overrides the bells. You can talk to all floors by pressing the "All Call" button or you can talk to certain floors only by pressing the appropriate floor number.

Firefighters' telephone allows private conversation to any one floor or a number of floors. IT IS THE POLICY OF THIS DEPARTMENT THAT WE DO NOT RESET THE SYSTEM.

6. FIXED SYSTEMS

A Fixed Extinguishing System is one that can be activated by automatic detection or manually. The extinguishant could be any of the following:

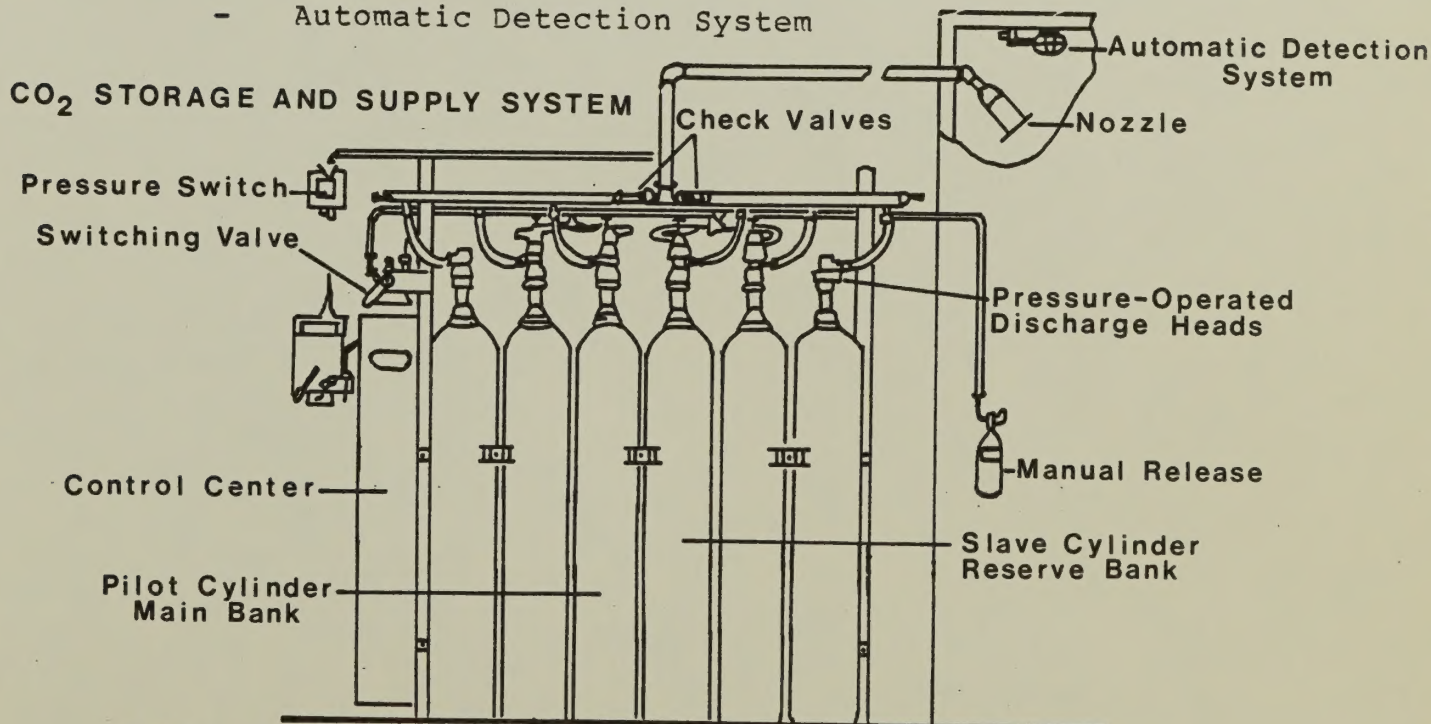
(1986)

- Foam
- Carbon Dioxide
- Dry Chemical
- Halon

The most common use for a Fixed System is over cooking equipment.

The main components of a fixed system is as follows:

- Control Centre
- Main Bank
- Reserve Bank
- Pressure Switch
- Manual Release
- Nozzle
- Automatic Detection System



A high pressure carbon dioxide storage bank consists of a set of controls and switches, main and reserve supply cylinders and a manual operation station.

NOTE: FOR ADDITIONAL INFORMATION, REFER TO I.F.S.T.A. MANUAL.

(1986)

CHAPTER 20

LIFE NET

1. INTRODUCTION

The life net used on the Hamilton Fire Department is the 2.8 metre Atlas or Browder life net and is carried on the apparatus in a quarterly folded position.

The net should be removed from the apparatus every Sunday, on the day shift, inspected for dampness, defects in canvas, springs and locks, etc. A light oil should be used on the locks in small quantities. The locks and springs must be kept free from rust and dirt. After every exposure to water, the net must be removed from the apparatus, opened and allowed to dry.

2. USE OF THE LIFE NET

The life net is used only in extreme emergencies when it would be more practical to attempt to catch a person in the net, than it would be to place ladders for the rescue. In some cases, such emergencies would exist where loss of life is imminent and the few minutes it would require to raise ladders may be the difference between life and death, or where a large number of people are attempting to escape a burning building and it is impossible to raise sufficient ladders to remove them in time to save their lives.

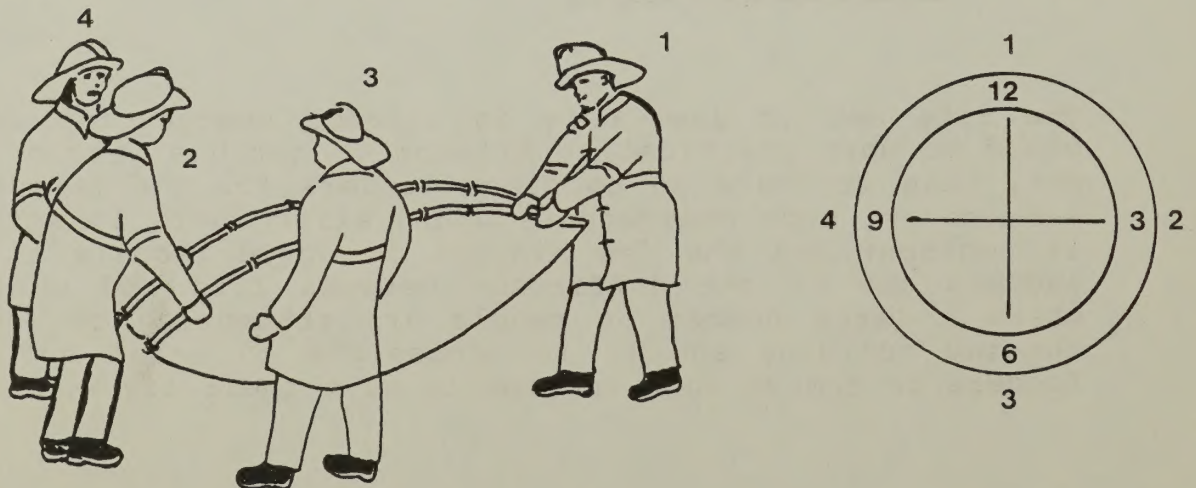
(1986)

In removing the life net from the apparatus, precaution must be taken that the net is properly unfolded and locked, AT THE APPARATUS. The net should never be unfolded or locked under the person that is going to make a leap, as excited individuals are apt to jump into the net before it is securely locked.

The net should never be dragged when folding or unfolding as the canvas is often worn out in the most vital part, the centre. The locks must not strike the pavement or soft ground, as they may be damaged or become clogged with dirt.

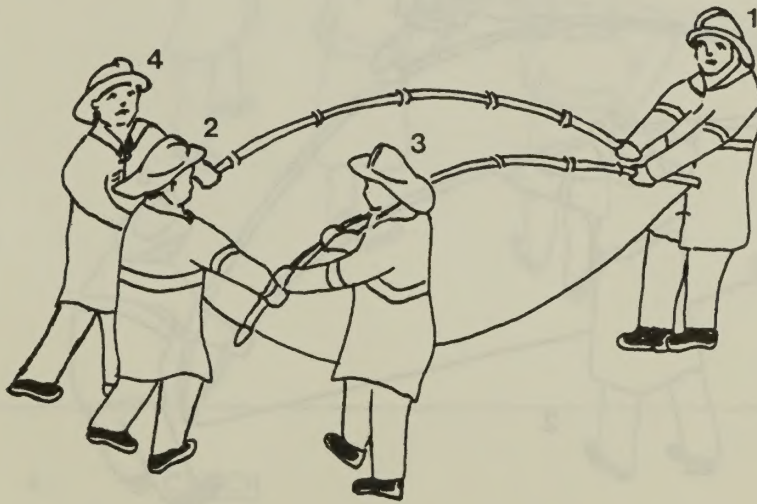
3. OPERATION OF THE LIFE NET - OPENING

1. Nos. 1 and 2 men will pick up the net. No.1 taking the closed end and No.2 the open end. No.3 man will take a position to No. 2's right and No.4 will take a position on No.2's left.

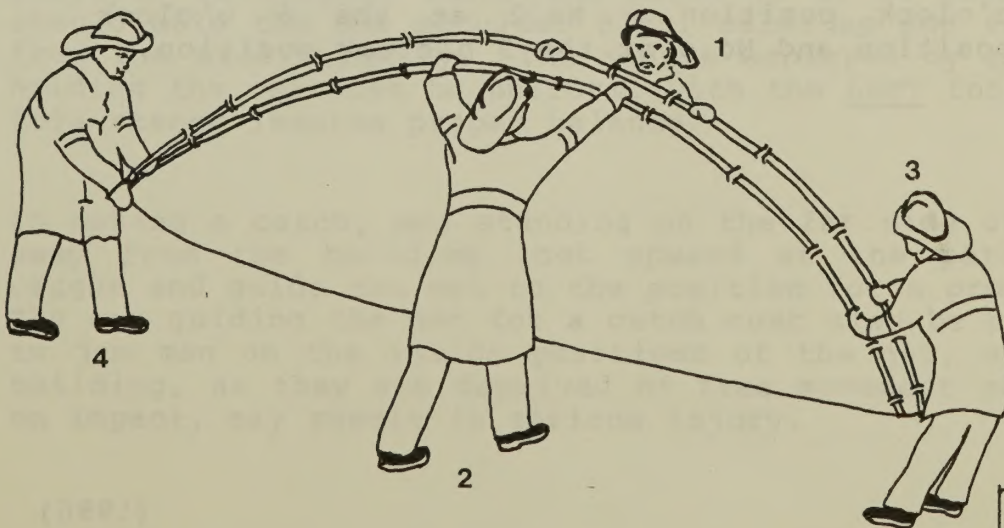


(1986)

2. No.2 will pass the right wing of the net to the No.3 and the left wing to No.4 simultaneously.

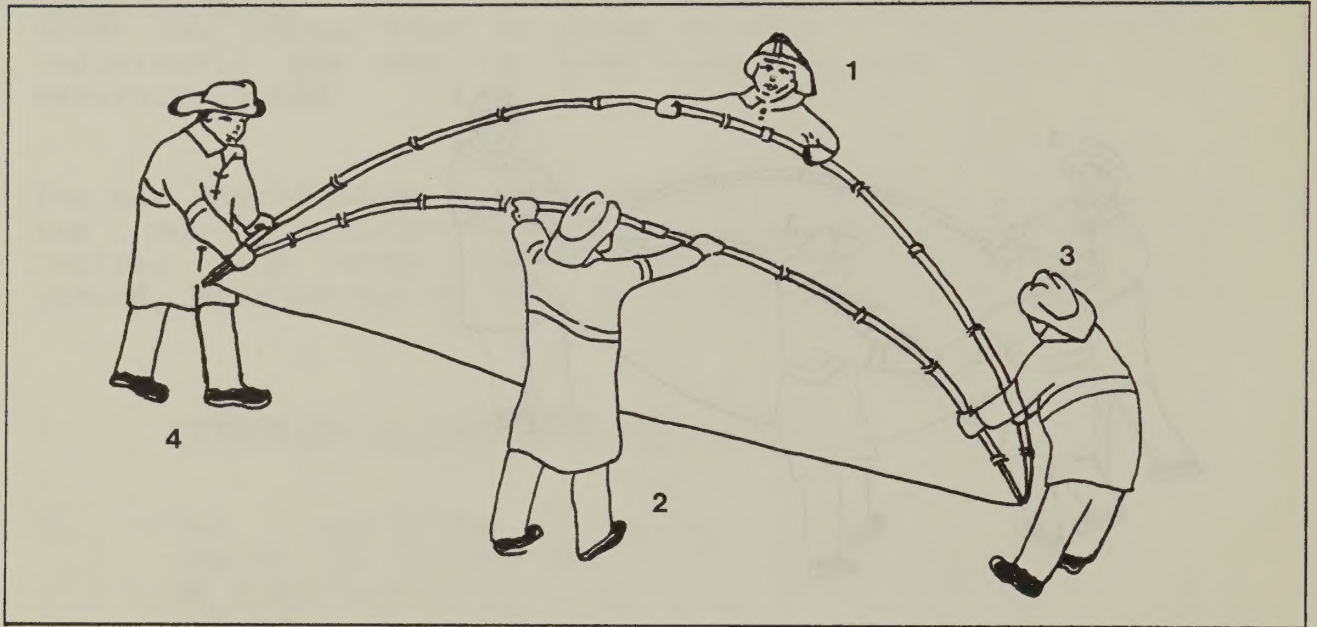


3. No.3 and No.4 will spread out in position to open the net.



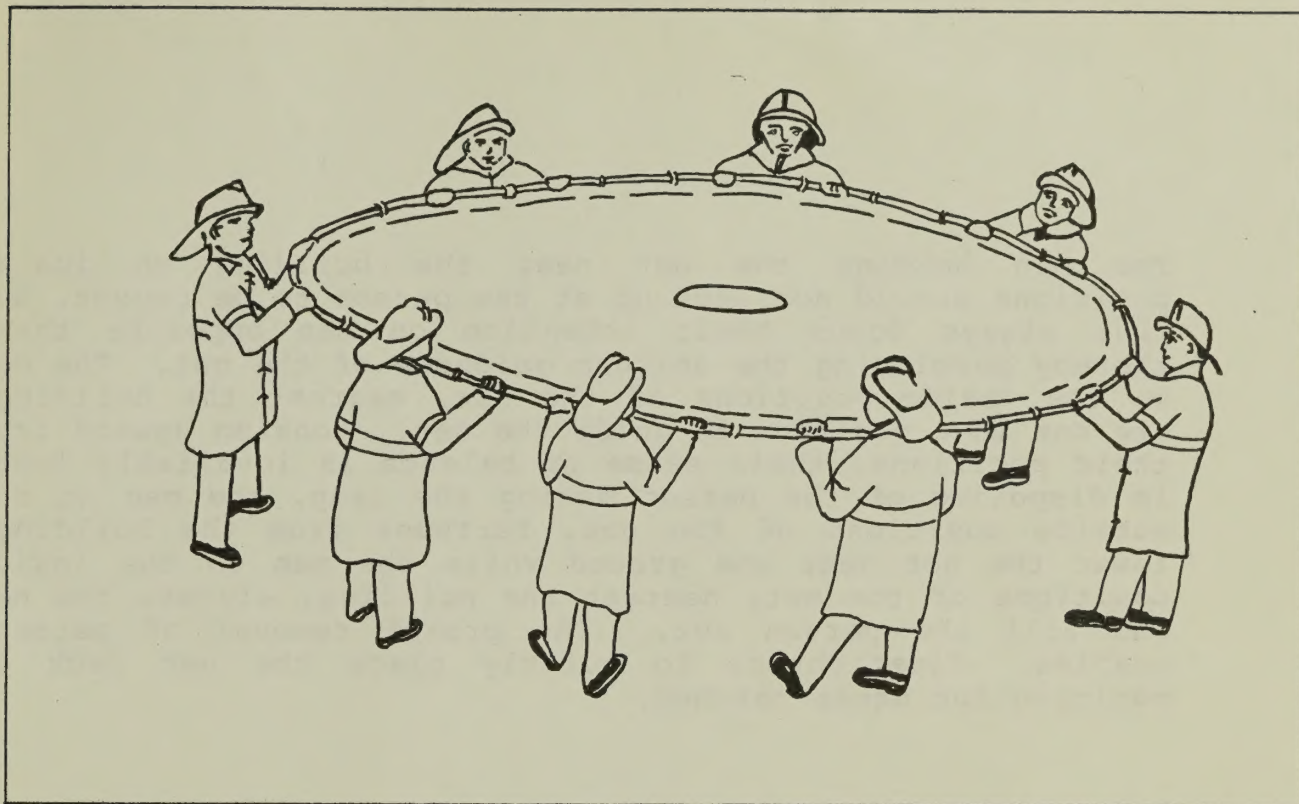
(1986)

4. No.2 man will step forward and grasp his lock (or section of the net) from No.1 man.



5. After the net is opened, Nos. 1, 2, 3, and 4 will take one step to the right, so as not to straddle the locks. At this point, the next four men will take positions between the men on the locks. Now there are eight men in proper position on the net; however, only four of these positions are numbered. No.1 at the 12 o'clock position - No.3 at the 3 o'clock position - No.2 at the 6 o'clock position and No.4 at the 9 o'clock position.

(1986)



4. CATCH

In running with an open and locked net, the men who are nearest the building where the rescue is to be effected, should about face and run facing the direction of travel, holding the net with one hand at shoulder height, and using the free hand and arm to brush aside spectators, etc. This also enables runners to notice objects, such as curbs, fences, etc. The men on the opposite side will keep both hands on the net and will follow the men in lead. After the position is reached where the catch is to be made, the men should hold the net shoulder high, palms up and elbows away from the side slightly. The stance employed by all persons holding the net must be uniform, with the LEFT foot forward. This stance insures proper balance.

In making a catch, men standing on the far side of the net, away from the building look upward at the person to be caught and guide the net to the position for a proper catch. The men guiding the net for a catch must also be careful not to jam men on the inside positions of the net, against the building, as they are deprived of free movement of arms and on impact, may result in serious injury.

(1986)

The men holding the net near the building on inside positions should not look up at the person to be caught, but must always focus their attention on men opposite them, thereby permitting the uniform guidance of the net. The men on the inside positions of the net, nearest the building, are not in a position to guide the net. Looking upward from their positions, their sense of balance is invariably lost. In disposing of the person making the leap, the men on the outside positions of the net, farthest from the building, lower the net near the ground while the men on the inside positions of the net, nearest the building, elevate the net and roll the person out. The prompt removal of persons enables firefighters to quickly place the net back in position for other catches.

5. CALCULATING THE FORCE OF IMPACT

A single method for calculating this kinetic energy is to multiply the height of the jump by the weight of the person jumping.

6. CLOSING THE NET

(No.2 lock in downward position.) The four men that are between the locks fall out. Lock men take one step to the left, straddle locks, hold the net on their knees while No.3 and 4 men break the locks. No.1 and 2 men lift their half of the net to a vertical position with the locks about 15 cm apart. Then No.1 and 2 men break their locks, bringing the net back to the "CLOSED POSITION."

NOTE: FOR ADDITIONAL INFORMATION REFER TO THE
I.F.S.T.A. MANUAL

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